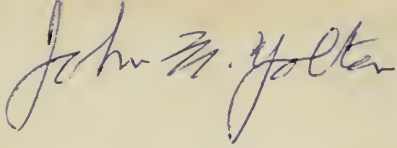

# MATHO:

OR, THE

# *Cosmotheoria Puerilis,*

A

# DIALOGUE.

IN WHICH

The first Principles of PHILOSOPHY and ASTRONOMY are accommodated to the Capacity of young Persons, or such as have yet no Tincture of these SCIENCES. Hence the Principles of Natural Religion are deduced.

*Translated, and enlarged by the* AUTHOR.

VOL. II.

*Nam corpus hoc animi pondus & pœna est: Premente illo urgetur; in vinculis est, nisi accessit Philosophia, et illum respirare rerum naturæ spectaculo jussit——Vetas me cœlo interesse, id est, jubes me vivere capite demisso.* Seneca.

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MDCCXLV.

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THE

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## The Eighth CONFERENCE.

Matho *desires to know why the Secondary Planets might not have revolved separately about the Sun, as the immediate Center of their Motion? If the Distance of the Satellites from their Primaries had been greater or less, what must the Consequences have been? That there may be more Bodies in the Solar System than are discoverable by us. In what Proportion the centripetal Force is increased or diminished, as the Planet is nearer to, or more remote from, the Sun. From what Causes the centrifugal Force becomes greater or less. It is shewn necessary, by bringing the centripetal and centrifugal Forces to an Equilibrium, that the Cubes of the Distances of the Planets from the Sun must be as the Squares of their Periodical Times. And contrarily, as this Proportion holds in fact, from thence it is shewn, that the centrifugal, and therefore the centripetal, Force must be inversely as the Squares of the Planets Distances from the Sun.* p. 65, 66.

The

## The Ninth CONFERENCE.

*What must have been the Consequences if the Moon had moved in a Plane crossing the Ecliptick, or Plane of the Earth's Orbit, at right Angles. That our Earth is a Moon to its own Satellite, appearing to her near* 16 *Times larger than the Sun himself, and thereby throwing on her a vast Gleam of Light.* Jupiter *appears to the innermost of his Satellites* 1600 *Times larger than the Sun does to us; and* Saturn *more than a* 1000 *Times larger to his nearest Satellites: They must therefore throw a prodigious Splendor on their own Moons. That the Planets both Primary and Secondary are thus carefully illuminated, shews they are not empty Seats; but designed for Habitation: For* Light, *in the Nature of Things, answers to* Eyes. *A skilful Artist could not design that which is more noble for the Use of what is of an inferior Nature. The whole material Universe was therefore made for the Sake of Rational Beings. That our Sun at the Distance of* Sirius *or* Arcturus

Arcturus *would appear but like one of the fixed Stars, and the solar Planets be quite absorbed by the immense intervening Space. The great centrifugal Force on the larger Planets a Relief to their Inhabitants, as suspending a considerable Part of their Weight on those vast Bodies. The Density of those great Bodies wisely contrived in being less than in smaller Bodies, upon this Account. An easy Way to calculate their Quantities of Matter and Densities.*

The Tenth CONFERENCE.

*As the Weight of Bodies on the lesser Planets is but small, their Rotation on their Axes is slow, and their centrifugal Force but weak. Heat and Light are dispensed rather according to the Surface, than the Quantity of Matter in the luminous Body; hence the Sun is but of a moderate Density. That the outermost and innermost of the Planets are not uninhabitable by Reason of the Extremities of Heat or Cold. Heat is not always in Proportion to our Vicinity to the Sun: Cold requires a positive Cause, or something more than the mere*

*mere Abſence of Heat. The Extremities of both may be qualified by the Conſtitution of an Atmoſphere. That all the Planets are ſurrounded with Atmoſpheres. The phyſical Explication how Bodies may deſcribe elliptical Orbits about an attracting Body, placed either in the Center of the Ellipſis, or in one of its Foci; according as the Law of Attraction is ſuppoſed different. Theſe two Caſes compared between themſelves, and the Tranſitions from the one to the other ſhewn natural and eaſy. The Proportion between the Squares of the periodical Times and Cubes of the middle Diſtances, ſtill obſerved when Bodies revolve in Ellipſes. The Comets revolve by the ſame Laws, and obſerve the ſame Proportions as the Planets. —— Of the Immortality of the Soul. That the Soul is not aſſiſted to think and perceive by Organs of a dead Subſtance; but is by theſe confined and limited to a particular Manner of Action and Perception. Whether the Deity could cut off rational Beings, for whoſe ſake the material World was created, the Frame itſelf ſtill remaining. The Deſire of Exiſtence the Foundation of all our other Deſires, and the Source of all*

*great and virtuous Actions. A happy Existence the only Object of Desire in the Nature of Things. Utter Extinction no Object of Desire. The Disingenuity of the Atheist. The Mistake of those who separate Virtue from a Love to ourselves. Atheists could not live together in Society on their own Principles. The false reasoning in Mr.* Bayle's *Apology for the Atheists. The Atheists Account of the Rise of Religion. The Wonders in the material Creation designed to instruct Beings appointed for Immortality. The material Creation the inferior, and least wonderful Part of the Works of God.*

MATHO:

# MATHO:

OR, THE

# *Cosmotheoria Puerilis,*

A DIALOGUE, &c.

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## THE

## Seventh CONFERENCE.

Matho *and* Philon *resume the Discourse concerning the Planetary System. Of the compound motion of the Satellites round their Primary Planets, and with their* Primaries *round the Sun. A Body, that it may revolve about a Center, (which Center itself revolves about another Center) must indesinently be urged by four different Forces; two with respect to each Center. That each of these Forces is constantly impressed (or at least successively renewed) by an* immaterial Power, *and not owing to one original impulse. Of that* Limit *between the Sun and any Primary Planet, where their attractive*

*Forces are equal. That any Secondary Planet must revolve within that Limit: or, the Orbit of the* Secondary *must lye between that Limit and its Primary.*

## *MATHO, PHILON.*

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XCII. *M.* I AM come back to you, *Philon*, full of a grateful Sense of your Favours; for I reckon it a Happiness that I addressed my self first to you.

*P.* What sort of an Introduction is this; or why do you reckon that such a Happiness?

*M.* Because now I think I understand some things of no small Consequence, which before I knew nothing of.

*P.* How much of this do you owe to me?

*M.* The whole certainly.

*P.* Your Reckoning seems to be wrong.

*M.* How comes it to pass then that I now understand what formerly I was quite ignorant of?

*P.* When one has to deal with a Person of good natural Sense, *Matho*, the whole Secret of Teaching consists in putting proper Questions to him. It often happens, that by our seeming to doubt of plain things, we provoke him to defend the Truth he knows, and to discover the Consequences of it, which formerly

merly he did not attend to: This is all the poor Service I have done you. Seventh Conference

*M.* We are more effectually instructed, I believe, by such *pretended Doubting*, than by direct and ready answers; as this Method interests us more in the Enquiry.

*P.* But it is not every one, I can assure you, who is capable of being instructed in this manner.

*M.* And yet I have heard, some of the *ancient Philosophers* were of Opinion, that any Person might be instructed, by putting Questions to him in a natural and dependent Order.

*P.* Yes; those Philosophers, who supposed that all the Knowledge we acquire here, is only *Reminiscence* of what we understood in a former State: If so, some of us did not, it seems, understand much then, and remember less now.

*M.* Nay, *Philon*, to leave joking, if I might dispute the Point with you, I think I could shew this to be true on your own Principles.

*P.* On my Principles?

*M.* Yes: For since you allow that we are purely passive in perceiving the Agreement or Difference of our Ideas, after they are carefully formed, and clearly seen; it will follow that any one must necessarily see the Truth, provided his *Teacher*, by proper and natural

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Queſtions, can excite in his Mind juſt Ideas of the Point in Agitation between them.

*P.* Is this the Subject, which, when we parted, you ſaid we were to talk upon in our next Conference?

*M.* I deſiſt then: But remember, you have the better of me in this Argument, not by your Reaſons, but by your Authority.—Now to come to the Particulars concerning which I wanted to be informed: You ſaid, in deſcribing the Bodies in our ſolar Syſtem, that the *Moon* rolled twelve or thirteen times about the *Earth*, while that was carried round the Sun in its annual Courſe. This Motion of the *Secondary Planets* round their Primaries I do not well underſtand: I cannot conceive how the *Moon* ſhould be carried along with the *Earth*, and roll about it at the ſame time. Beſides, I would know why the Moon revolves about the Earth at all; and not rather about the Sun ſeparately, as a Primary Planet. What Reaſon can be aſſigned, why *Jupiter*'s four Moons, or *Saturn*'s five, do not immediately direct their Courſe about the Sun, the common Center of the whole Syſtem; inſtead of regarding thoſe other Planets as the Centers of their Motions?

*P.* You know, as *Satellites*, or *Guards*, they muſt be obliged to a conſtant perſonal Attendance. *M.* Pray,

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*M.* Pray, *Philon*, leave off jesting, when we come to speak of serious Matters. You promised likewise to shew me how the powerful Action of the Sun, through the whole System, does not disturb the Motions of these *lesser Systems.*

*P.* Pardon me, *Matho*; I was not so rash neither to make such a Promise. I did not refuse to discourse with you on any Subject you should propose; because you said, while we conversed familiarly, and without Reserve, many things offered to us, which otherwise would not have occurred: But I dare not pretend to give you Satisfaction in those things. The *compound Motion* of the *Secondary Planets* is one of the most intricate Points I know, and hardest to be conceived: Nor are the other Things you mention less, but rather more difficult.

*M.* I am aware of the Difficulty of the first Particular: But this whets my Curiosity the more.

*P.* To give you what Assistance I can then: With respect to the Motion of the Secondary Planets round their Primaries, you saw before, or rather found out from Arguments of your own, That the celestial Bodies have their globular Figure from the mutual Attraction between all their Parts; and

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that this Attraction does not ceaſe at their Surfaces, but prevails through a certain ſpherical Space round them, according to the Quantity of Matter each of them contains. Hence comes the *Relative upward* and *downward* belonging to every particular Planet in our Syſtem; from which Relation this Attraction is called Gravitation; for Gravitation is only a relative Term. And from this *particular Attraction* it is, that the Satellites roll round their Primary Planets, the ſame Way, and by the ſame Laws, as the Primary Planets do round the Sun: Therefore where there are more Satellites than one, the Squares of their periodical Times, about the great Planet, are as the Cubes of their Diſtances from it; juſt as it is with reſpect to the Times of the Primary Planets about the Sun, and their Diſtances from him.

XCIII. *M.* This I remember, and ſee plainly enough that their circular Motion muſt be cauſed by a gravitating and projectile Force conſtantly acting upon them: This holds univerſally in all Bodies revolving about a center in free Spaces. But then, how do you combine with this Motion, that other, whereby they are carried along with their *Primaries* round the Sun? Or is the Attraction of their

*Primaries*

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*Primaries* strong enough to carry them thus along through their own larger Orbits, without any other Force impressed?

*P.* By no means.—But to help your Imagination in this Affair, suppose at first that the Sun is quite absent, and that the *Primary* remains as an immoveable central Body instead of the Sun.

*M.* What then?

*P.* In this Case, the gravitating and projectile Forces being impressed on the Satellite, you see it must revolve about its *Primary* (now standing still) just as the Primary it self revolved about the Sun before.

*M.* The same way indeed; for there is no Difference between the two Cases.

*P.* Imagine then that the *Primary* is impelled straight forward, together with its *Satellite*; a Force being impressed on both by *some skilful* and *mighty Hand*, always in parallel Directions; while in the mean time the two former Forces (namely, the *gravitating* and *projectile)* act constantly on the Satellite, as before this last Force was impressed: And consider then what will be the Result.

*M.* The *Satellite* is now urged by three Forces: *This last* carries it forward in a parallel Direction with its Primary; and by the *two first* it must still roll round its Primary. I

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ſuppoſe, as if neither *that* nor itſelf were impelled forward. But there is ſomething here which I do not fully conceive.

*P.* Leave particular Niceties 'till another time, and endeavour at firſt only to get a general Notion of the Caſe. In the main it is as you ſay: For we may be ſure that no one of the *three Forces* impreſſed can be without its Effect, more than if they had been impreſſed ſeparately on three different Bodies. Now keeping theſe things in your Mind, imagine the Sun to be brought back to his Place again; and then conſider what will enſue.

*M.* The Sun being replaced, Gravitation towards him muſt begin to act on both the *Primary* and *Secondary*; and the excurſory or projectile Force (by which, to wit, both were impelled ſtraight forward in parallel Directions) was impreſſed on both before. Whence, ſince they are, by Suppoſition, at a due Diſtance from the Sun; ſo that neither his Attraction nor their excurſory Tendency can overcome the one the other; they muſt begin, I think, to roll round him; while in the Interim the Satellite continues to perform its leſſer Rotations about its Primary, as before.

*P.* You trace out the Conſequences very diſtinctly; and from this you will be able to form

form a Notion, how such a complex Motion of the Satellite is effected. Seventh Conference.

*M.* I conceive it indeed in some measure: But as there are four different Forces constantly impressed here on the Satellite; though I easily apprehend how it should be attracted to two different Centers; yet I can hardly reconcile in my own Mind the two different projectile Forces impressed on it; one with respect to its revolving about its own *Primary*, and the other with respect to its revolving along with *that* about the Sun; which must so often interfere and oppose each other. Pray might we not suppose that the larger Planet, while it moves on its own Orbit, attracts the Satellite or lesser Planet, so strongly, as to carry it along without any other Force impressed upon it?

*P.* By no means, I say: We must not make Suppositions contrary to the Reality of Things. If we take our *Earth* and *Moon* as an Example, we shall find *that Supposition* inconsistent with the Nature of the Moon's compound Motion: Nor is there any way of geting free from the constant Impression of these four different Forces (and therefore of the two different projectile Forces) upon her at once.

*M.* Then

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*M.* Then I see the Truth of what you said, That the compound Motion of the Satellites is harder to be conceived than any thing I have hitherto met with. But how does this constant Impression of two different projectile Forces appear from the Example of the *Earth* and Moon?

*P.* We observed before, if the Distance of the Earth from the Sun be 21000 of its own Semi-diameters, its Motion in its annual Orbit must be at the rate of 1000 Miles in a Minute: And it is certain that the attractive Force of the Earth upon the Moon could only draw her a little more than 16 Feet in a Minute. Now when the Moon is in her last quarter, that is, directly behind the Earth in its annual Orbit, she is not left behind the Earth, but moves with equal Velocity, or after the rate of 1000 Miles in a Minute; and yet could only move in the same Direction so small a Space as 16 Feet by the attractive Force of her Primary Planet.

*M.* This is an enormous Difference!

*P.* It is indeed; and though we should suppose the Distance of the Earth from the Sun less, and therefore its Velocity less; the Difference would still be enormous.——In advancing from this Point of her Orbit to her Conjunction with the Sun, she is there as far for-

forward with respect to the annual Course of the Earth, as the Earth itself is.

*M.* I understand; for she is now got between the Earth and the Sun.

*P.* Therefore in about seven Days Time, besides moving at the rate of 1000 Miles every Minute, she hath gained upon the Earth nearly 240000 Miles, or the whole Semidiameter of her own Orbit,

*M.* It is so.

*P.* But this is the Effect of a different projectile Force; in her own Orbit, to wit: For the Attraction of the Earth could not have brought her so far forward. This Attraction (as has been said) could only have drawn her 16 Feet in any Minute, and that toward the Center of the Earth: Whereas here (considering her Motion as parallel to the Earth's) she hath moved about 22 Miles in a Minute, over and above the 1000. For 240000 Miles in 7 Days 9 Hours comes much to this.

*M.* Go on. This is plain.

*P.* In moving on to the first Quarter after the Conjunction, she is now got directly before the Earth in its annual Course, as about 14 or 15 Days before she was behind it: Therefore she has gained on the Earth another 240000 Miles. And in this Part of her Orbit she moves on in the annual Course 1000 Miles

in

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in a Minute, directly contrary to the Earth's Attraction.

*M.* I see it clearly.

*P.* In ascending to her Opposition with the Sun, when she appears full, she hath lost 240000 Miles, with respect to the Velocity of the Earth's Motion; or the Earth is as far advanced in the annual Course as she: And in returning to the first Point again, that is to her last Quarter, she hath lost 240000 Miles more: The Reason of which is easily seen. In all these Cases, her rapid Motion in attending the Earth, you find, is not in the least affected by her Gravitation towards it. That does no more than balance her centrifugal Force in her own Orbit.

XCIV. *M.* You have now fully convinced me of the Necessity of impressing both these projectile Forces on the secondary Planet, especially the *first*, with respect to its Motion about the Sun, always in a parallel Direction to the Motion of its Primary; and at the same Time you have raised in me an Admiration of a Motion so complex, and skilfully maintained by a constant Variation.

*P.* Let me know what you understand by its being maintained by a constant Variation?

*M.* I

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*M.* I am afraid I shall not be able to express clearly a Thing which in its own Nature is not easy to be conceived.

*P.* It sometimes so happens indeed: But in such Cases Allowance is to be made, and the Words are supposed to convey more than they express.

*M.* While the Moon here moves in her own Orbit round the Earth, a prodigious Force is constantly impressed upon her, which hath no Relation to her Motion in that Orbit, but to her moving in a parallel Direction with the rapid Motion of that very Body, about which she must at the same Time revolve. Now that this parallel Motion to, and periodical Motion round the same Body, should be made consistent, appears to me wonderful above Expression; and requires a constant, and nicely adjusted Variation of this parallel Impression in every Point of her Orbit.

*P.* Go on; I conceive what you say very easily.

*M.* As the Motion of the Earth is in a circular Orbit, an Impression of Force parallel to the Direction of such a Motion must be changed, and therefore renewed every Minute, as the Direction of the Motion itself is changed in every Point. When we look round, there is no Attraction here, nor stated mechanical

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chanical Law ſuppoſing Attraction were *mechanical)* to ſuperſede this conſtant Impulſe in a different Direction: For you ſhewed abundantly juſt now, that the attractive Power of the Earth doth not in the leaſt contribute to it. And this *parallel Impreſſion* itſelf is to ſupply the Place of a projectile Force; as we ſaw, when it was firſt impreſſed on the *Primary* and *Satellite*, before the attractive Force of the the Sun was ſuppoſed to act. So that the Impreſſion of this Force (as was ſaid) is to be changed, and therefore renewed every Minute, by an *immechanical Cauſe* *——Beſides, while the Moon moves regularly round her *Primary*, in her proper Orbit; ſometimes ſhe gets before it, ſometimes ſhe returns back, anon ſhe overtakes it; and often ſhe moves obliquely, or croſe-wiſe. Hence this *parallel Impreſſion* muſt ſometimes be ſtronger,

* Leſt it ſhould be here ſurmiſed, that the attractive Power of the Sun may be ſufficient ſo to affect *this Force* impreſſed on the Moon, as always to bend her Motion into a Direction parallel to the Orbit of the Earth, in a mechanical Manner, and without a new Intervention of Divine Power; let it be conſidered that if, in the Conjunction, the Sun's Attraction were thus ſufficient to bend the Moon's Motion into a Direction parallel to the Earth's Orbit, (that is, into a concentrical Circle;) the Moon could never turn up again towards the Earth's Orbit, or leave that Circle. And if the Sun's Force be not ſufficient to give her Motion ſuch a Bent in the Point of Conjunction, it cannot be ſufficient when the Moon is at a greater Diſtance.

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sometimes weaker, and the Quantity of it constantly varied, according to the different Part of her Orbit she moves in; or there is an inconceivably nice Composition of two different Impulses (the projectile Force, I mean, in her own Orbit, and this *parallel Impression*) whereby they sometimes conspire, are sometimes directly opposite, and often the one is made side-wise to the other. When their Directions conspire in the Conjunction, what separates them again? When they are contrary in the Opposition, what renews the lesser Force which is once quite destroyed? When the Directions are oblique, what preserves both Forces entire? There is nothing here like the *Axiom* you once told me of, *That a Body partakes of the Motion of its Place.* The Place of the Moon's Orbit is pure Space, which can neither be moved, nor impress a Force on any Body moving in it. From this it appears to me that not only the *parallel Impression*, but the Moon's projectile Force in her own Orbit, is still preserved the same, not from any mechanical Cause, but the constant Action of the Deity. And since both these Forces are always impressed, or renewed, in such due Proportion that the one of them no more disturbs the other (in their Effects I mean) than if it were not impressed, I cannot enough admire

this

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this new Instance of the divine Power and Wisdom in the Motions of these secondary Planets.

*P.* You have expressed this complex Appearance, *Matho*, as clearly to my Apprehension as the Nature of the Thing will allow. In the *Conjunction* the Moon's Motion in her own Orbit conspires with this parallel Impression, and adds to its Celerity; in the *Opposition* her menstrual Motion is contrary to the other, and retards it; in all other Points of her Orbit they are oblique, less or more, and affect each other accordingly. But whether you conceive that the *parallel Impression* is made sometimes stronger, sometimes weaker; or that both Forces are still kept up to the same Quantity; we must still have Recourse to the immediate Power of the Deity, and give up all Explications by mechanical Causes. If the *parallel Impression* on the Satellite were not incessantly renewed in a different Direction, according to the circular Orbit of the *Primary*, these two could not keep together in one System: Or if the Moon's proper projectile Force were not constantly renewed after the Opposition, she could no longer roll about the Earth. For in that Point the weakest Force must be destroyed.

*M.* And

*M.* And this constant Miracle becomes manifold where four or five Satellites revolve about the same primary Planet: So that the Mind, which can hardly conceive this wonderful Adjustment of Forces in the simple System of the Earth and Moon, is quite confounded with the Variety of them in the more complicated Systems of *Jupiter* and *Saturn*.

*P.* and what is still more wonderful, *Matho*, this constant renewing of the *parallel Impression* will not be peculiar to the *Satellite* alone; but common to it with its Primary; if the secondary Planet does not precisely revolve about the Center of its Primary, but together with the Primary rolls about a certain Point between them, called their *common Center of Gravity*. In this Case the tangential or projectile Force of the larger Planets, which hitherto we have supposed to be owing to one original Impulse, given them at the Beginning of their Motions, will as much require a constant Variation of Impression, as that of the *Secondaries* themselves.

XCV. *M.* Pray explain this Particular; for I am quite a Stranger to what you call the common Center of Gravity of two Bodies.

*P.* In Truth I'm afraid lest it should fatigue your Imagination too much, which can-

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not now be ſo briſk and ready as when we began: And this is no eaſy Speculation to one who has never heard of a Center of Gravity before.

*M.* If I do not underſtand what you ſay I ſhall be no wiſer than if you had ſaid nothing at all.

*P.* You muſt know then that the Center of Gravity of two Bodies (not to ſpeak of more) is ſuch a Point between them, about which if both roll, their centrifugal Forces will be equal, or balance each other; ſo that neither can carry off the other by its ſtronger Tendency to recede from the Center of its Motion. And therefore this Point is ſo much farther diſtant from the Center of the leſſer Body, as the Quantity of Matter in the other is greater: or (which comes to the ſame Thing) it is ſo much nearer the Center of the greater Body, as the Quantity of Matter in the other is leſs.

*M.* Give me an Example of this?

*P.* If the Quantity of Matter in the Earth be forty Times more than that in the Moon, their common Center of Gravity will be forty Times farther diſtant from the Center of the Moon, than from the Center of the Earth; that her larger Swing in moving round this Point may make up what ſhe wants in Matter to balance the centrifugal Force of the Earth, and

and hinder her from being drawn away. For a fortieth Part of the Matter with forty Times the Celerity will be equal to forty Times the Matter with once the Celerity. Therefore if we suppose the Distance between the Centers of the Earth and Moon divided into forty one equal Parts, their common Center of Gravity will be forty of those Parts distant from the Center of the Moon, and only one of them distant from the Center of the Earth.

*M.* I think I have a Notion of this from some Sort of Balances I have seen; where a Weight half as great only as another, was yet a counter-poise for that other, provided it were placed twice as far from the *Point* by which the Balance was suspended; here, I conjecture, half the Weight with twice the Celerity was equal to twice the Weight with once the Celerity.

*P.* You are very right: This is a good Example to give you a familiar Notion of the Center of Gravity of two Bodies.

*M.* But what do you mean by the Center of Gravity of more Bodies? For you mentioned that also.

*P.* In your Example you know if the two Bodies be suspended by their common Center of Gravity neither of them will over-balance the other, more than if they were both placed in that Point.

 *M.* Nei-

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*M.* Neither of them will.

*P.* Suppoſe then the *Beam* long enough, and a *third Body* (equal, for Inſtance, to a tenth Part of the Weight of both theſe Bodies taken together,) placed on the Beam at a Diſtance from them.

*M.* What then?

*P.* Then the Center of Gravity between this *third Body* and the *former two*, conſidered now as one Body, will be ten times more diſtant from *it*, than from their Center of Gravity: So that if the Beam were now ſuſpended by this Point, this *third Body* would be a counter-poiſe for both the former Bodies.

*M.* Then you ſuppoſe the *two former Bodies* to weigh exactly as if they were placed in their common Center of Gravity, in Order to find out the Center of Gravity between them and this third Body?

*P.* Exactly the ſame Way.

*M.* And *this Point* laſt found will be the common Center of Gravity of all three?

*P.* It will.

*M.* And if I were to find out the Center of Gravity between *theſe three* and a *fourth*, I ſhould ſuppoſe all three ſuſpended, or placed at their common Center of Gravity, and proceed as before; that is, as if there were but two Bodies?

*P.* You

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*P.* You have it.

*M.* This is both easy and pleasant.—— Pray let me mention a Particular I have often observed, which I think has some Relation to this.

*P.* I shall be glad to hear it.

*M.* When I have struck against any Thing with a Stick, if the Stroke was too near my Hand, or too near the End of the Stick, my Hand was strongly shaken some how, and I felt Pain from the Stroke; but otherwise it was easy and not painful to me.

*P.* In this Case, *Matho*, there is a Point in the Stick, or in any Thing with which you strike, called the *Center of Percussion*. When the Stroke falls on *that Point*, it is smooth and easy to the Hand; for the Parts of the Stick on each Side balance each other, and the Thing against which you strike receives the whole Force of the Blow. But if the Stroke falls too near your Hand on this Side, or too near the End of the Stick on the other, your Hand bears a Part of the Force, and is severely shaken by it, which occasions Pain.

*M.* And whereabouts in this Stick may this Point, or *Center of Percussion* lye?

*P.* About two thirds of the Length of the Stick from your Hand; or one third of it from the other End.

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*M.* Then this gives me ſome Idea of the Center of Percuſſion.——

XCVI. But to return; Why do you ſuppoſe that the Earth and Moon ſhould revolve about their common Center of Gravity, rather than that the Moon ſhould revolve about the Center of the Earth, which revolves about no Center but the Sun, the common Center of the Motion of all the primary Planets?

*P.* The Earth and Moon, you know, mutually attract each other; and if we ſuppoſe no other Action to intervene, which may hinder the Earth to yield to the Moon's Attraction, it is impoſſible the Moon ſhould revolve about the Earth at Reſt, without its being brought ſtill nearer and nearer to the Moon, 'till at length they come cloſe together.

*M.* I own I do not conceive this at all.

*P.* Imagine the Moon to roll about the Earth at Reſt, (no other Action intervening) and in that Caſe the mutual Attraction between them cannot bring the Moon nearer the Earth, becauſe ſhe has a centrifugal Force by her circular Motion, which hinders her from yielding to the Earth's Attraction: But the Earth having no ſuch centrifugal Force, as being ſuppoſed at Reſt, muſt yield to her attractive Power by little and little, 'till at length they meet each other. *M.* Thus

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*M.* Thus far I see: Their Attraction would grow stronger and stronger, as they drew nearer, till at last they rushed towards each other.

*P.* That would be the Consequence: But if, to prevent that, the Earth should have a projectile Force impressed upon it, in a contrary Direction to the Moon's, and with a proper Celerity (*i. e.* so that its Celerity might be a fortieth Part of the Moon's) then it will have an equal centrifugal Tendency, and their mutual Attraction will as little prevail upon it, as upon the Moon.

*M.* The Matter now is intelligible. If two unequal Bodies were tied together by a Rope or Cord, and a Force only impressed on one of them (the greater suppose) *That* would drag the other after it: But if a Force were impressed on both, side-wise to the Tension of the String, and in contrary Directions, so that the Velocity of the less were as much more than that of the greater, as the Quantity of Matter in it were less; they must both necessarily revolve about such a Point as made their centrifugal Forces equal; that is, about their common Center of Gravity.

*P.* You enter very naturally into the Thought.

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*M.* Since the greater Body must always be nearer the common Center of Gravity. This brings to my Mind *Tycho Brahe*'s System of the Planets, where the Earth was supposed in the Center, with the Sun rolling about it: Which was like supposing a Mill-Stone rolling about a Pebble.

*P.* I am glad you remember so well that this obvious Reason easily shews the Absurdity of that ingenious Fiction.

*M.* But in the present Case, why do you make such an Exception, *If no other Action intervene?*

*P.* Because a stronger Action than their mutual Gravitation might hinder the Earth from moving thus about their common Center of Gravity, and then the Moon must revolve about the Earth as the Center of her Motion.

XCVII. *M.* I conceive it: But then, how do you shew that, if both of them revolve about the Earth as their common Center of Gravity, the *primary Planet* must constantly receive a Variation of Impulse in a different Direction, as well as the Satellite?

*P.* You know then both of them revolve about a Point (their common Center of Gravity) which revolves about another Point, (the Center of the Sun:) In this Case therefore it

it is the Center of Gravity that describes a circular Orbit about the Sun, and neither the Earth nor the Moon, which revolve immediately about it.——Now, though their Center of Gravity were at Rest, both the Earth and Moon must receive a projectile Impulse in contrary Directions, and with different Velocities, (as forty and one, to wit,) about this Point; just as it was in your Example of the two Bodies tied together with the Rope or String: For if one of them only received an Impulse about *it*, and the other not; that other, wanting centrifugal Force to resist their mutual Attraction, would be drawn nearer the Body which had centrifugal Force.

*M.* I perceive it must be so.

*P.* This would be the Case if their common Center of Gravity were at rest, and the Sun absent. But that *this Point*, about which they roll, may be carried in a circular Orbit round the Sun, both of them must also receive an Impression always parallel to the circular Motion of *this Point*; just as the Moon, in the former Supposition, was to receive an Impression always parallel to the circular Motion of the Earth.

*M.* I begin to penetrate a little into the Matter.

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*P.* I ſay the Earth now, as well as the Moon, muſt receive an Impreſſion always parallel to the circular Motion of *this Point:* For if in the former Caſe the Earth's Attraction was not enough to carry the Moon along with itſelf round the Sun, without ſuch an Impreſſion; the Effect of that Attraction being but about 16 Feet in a Minute; ſo in this Caſe the Moon's Attraction would be leſs able to carry the Earth along, were not an Impreſſion made on it likewiſe; the Effect of her Force being but a 40th Part of 16 Feet in a Minute.

*M.* It is plain the Earth muſt receive an Impreſſion as well as the Moon.

*P.* Then the Direction of this Impreſſion muſt always be changed, and the Impreſſion itſelf therefore renewed, becauſe the Direction of the *moving Point*, to which it muſt ſtill be parallel, is always changed; ſince it deſcribes a circular Orbit round the Sun. For as, in the former Caſe, the Impreſſion made on the Moon was ſtill to be parallel to the Earth's circular Motion, and therefore ſtill to be renewed; ſo in this Caſe, the Impreſſion made on the Earth is ſtill to be parallel to the circular Motion of their *Center of Gravity*; and therefore ſtill to be renewed.

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*M.* You have now gone through the whole Argument, *Philon*, Step by Step, so clearly, that I perceive the Necessity of the Reasons all along; and it is as you said. This makes the *projectile Force* of the primary Planets, which otherwise would be owing to one original Impulse given them at the Beginning of their Rotation round the Sun, as much to require a constant Variation of Impression, as that of the Secondaries themselves. You raised my Admiration before, when in our preceding Conferences you shewed me by what wonderful Means a primary Planet revolves about the Sun: But now when I consider what constant Attention, and manifold Impressions it requires, to make *a secondary Planet* revolve about *a Center*, which itself must revolve about *another Center*; Words lend but a feeble Aid to represent my Astonishment. A simple circular Motion requires a constant Change of Direction, and therefore a constantly renewed Impulse: But when one circular Motion is blended with another, and both are wrought into one (if I may so say) in the same Body, without Disorder or Confusion; and when this amazing Composition is multiplied with the Number of Satellites in the same System; the Heart of Man cannot sufficiently admire the Wisdom of the

*Crea-*

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*Creator* in contriving, nor his Power and Goodneſs in the conſtant Execution of ſuch a wonderful Work!

*P.* Hence, *Matho*, it appears more and more evident, how little Satisfaction there is in Philoſophy, if we exclude the immediate Action of the Deity. The Knowledge of the Laws of Nature is only the Knowledge of the Laws by which the *Creator* acts in preſerving the Univerſe. We attempt an impoſſible Thing when we endeavour to explain theſe Motions without his immediate Action. And *even They* paſs over the Conſideration of many Particulars, who acknowledge the immediate Hand of the *Almighty* in conſtantly renewing the centripetal Impulſe; but imagine that the projectile Force once impreſſed on the Planets hath remained unvaried ſince the Creation of the World, without the farther Interpoſition of the Deity.

XCVIII. *M.* I think I now underſtand ſomething more of the compound Motion of the ſecondary Planets than formerly I did; or at leaſt I ſee how difficult ſuch a Motion is to be underſtood: And likewiſe from what you ſaid in the Beginning of our Diſcourſe, I fancy I can gueſs at the Reaſon why the Action of the Sun, though predominant over the

the whole planetary System, does not disturb, or confuse, the Motion of the secondary Planets, in these lesser Systems of *Saturn*, *Jupiter*, and our *Earth*. Seventh Conference.

*P.* What is the Reason you would assign, why this does not happen?

*M.* You observed then, from what we had said before, That the Attraction of the *great Bodies* in our System does not immediately cease at their Surfaces, but prevails through a certain spherical Space round them, according to the Quantity of Matter each of them contains; which occasions the *relative downward* and *upward* we have so often spoke of, peculiar to every great Body in the System. Hence I suppose, if a Body were placed in any of these particular Spheres, it would fall to that Planet within whose Attraction it were thus placed, and not to the Sun, or any other Planet. And on this account the Action of the Sun does not separate the Bodies in any of the lesser Systems; because the Satellites are within the prevalent Attraction of the Primary Planets about which they roll.

*P.* You go on here at a great rate, *Matho*, without any Assistance.

*M.* The Subject appears natural and easy, from what we have said before.

*P.* But

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*P.* But how could you ſatisfy another Perſon, that the Force, whereby a Satellite is retained in its Orbit about the Primary Planet, points to that Planet?

*M.* The ſame way that I could ſatisfy him that the Force, whereby the Primary Planets themſelves are retained in their Orbits about the Sun, points to the Center of the Sun. I ſee plainly an Impoſſibility that any Body ſhould move in a circular Orbit about a Center in a free Space, unleſs it were conſtantly urged by a Force pointed to that Center, compounded with a projectile Tendency, or a Tendency to recede from that Center in every point of its orbit. This muſt hold as much with reſpect to one Center as another; as much with reſpect to the Centers of the Primary Planets about which their Satellites revolve, as with reſpect to the Center of the Sun about which the Primary Planets revolve. You alledged indeed, as a Proof of this, that where there are more Satellites than one in the ſame Syſtem, the Squares of their periodical Times round the Primary, and the Cubes of their Diſtances from it, are in the ſame Proportion; which is the Law that obtains with reſpect to the Motions of the Primary Planets themſelves about the Sun: But whatever Strength there may be in that Argument, it depends on

you

you to make me understand it. Though even without that, the Case seems to be plain to Reason and common Sense. For tell me, does not the *centrifugal Force*, arising from the circular Motion, balance the *centripetal?*

*P.* Certainly.

*M.* If then the circular Motion were stopt, or if the Satellite had no centrifugal Force, what would be the Effect of the *centripetal?* Would it not draw down the Satellite to the Center of the *Primary?* Or in respect of *what Center* is it a centripetal Force?

*P.* You prove this Matter convincingly enough.

*M.* And on this Principle it is, I suppose, that you said before, the Moon would be drawn down in a Minute some more than sixteen Feet, towards the Center of the Earth?

*P.* It is: And on the same Principle too Mathematicians shew, in what Time any of the Satellites would fall to the Center of its Primary; or in what Time the Primary would fall to the Center of the Sun.

*M.* There must be something therefore under this Question, since it is so plain; otherwise you had not made a Question of it: and I must endeavour to be upon my guard.

*P.* Tell

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*P.* Tell me next, How are these particular Spheres of Attraction of the Planets separated from the general Attraction of the Sun, which obtains over the whole Planetary System?

*M.* As the Attraction of any Planet (our Earth, for Instance) draws a Body towards its Center, and the Attraction of the Sun draws a Body towards his Center; there must be a *Limit* betwixt them, where the contrary Attractions are equal, and where, if a Body were placed, it should have a Tendency to neither. From the Earth on the one Side, or the Sun on the other, to this Limit is *upward:* And contrarily, from this Limit to eitheir s *downward.* Gravity therefore (as you observed) is but relative, and no way essential to Matter: since a Body placed at this Limit would gravitate to neither Center.

*P.* You are certainly in the right, *Matho:* For as the Earth attracts a Body at its Surface more strongly than the Sun attracts it; and as the Sun attracts a Body at his Surface more strongly than the Earth does; and since the Force of both Attractions decreases in a certain Proportion, as the Distance from the Sun or Earth increases; it must be, that in some certain Point between them their attractive Forces should be equal.

*M.* This

*M.* This is what I meant: And therefore if a Satellite keeps within this Limit, it must revolve about its Primary, within the Sphere of whose Attraction it is. Hence likewise I suppose, the greater the Sun's Distance is from the Earth, or any other Primary Planet; that is, the larger the solar System is supposed to be; the larger the Sphere of Attraction of the Earth, or any other Planet, must be of consequence; or, the farther *this Limit* between the Sun and it will be removed from any other Body in the System.

XCIX. *P.* It is very natural, *Matho*, for you to imagine so; but in Reality the thing is directly contrary to what you suppose.

*M.* Pray shew me my Mistake in this Particular.

*P.* I must first tell you that the Force of Attraction decreases in receding from the Center of the Sun (or of any other attracting Body) as the Squares of the Distances from that Center increase; and contrarily.

*M.* Explain this by an Example.

*P.* The Sun at twice the Distance attracts a Body but with a fourth Part of the Force, it would do at once the Distance; and at thrice the Distance, but with a ninth Part of the Force.

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*M.* I underſtand; and at four times the Diſtance, but with a ſixteenth Part of the Force: And ſo on.

*P.* It is ſo: And when the Diſtance is leſſened; at half the Diſtance he attracts four times more ſtrongly, at a third Part the Diſtance, nine times more ſtrongly, *&c.*

*M.* This is a Conſequence of the laſt Caſe.

*P.* Since then the Attraction decreaſes, as the Squares of the Diſtances increaſe; and increaſes as the Squares of the Diſtances decreaſe; both Caſes are thus briefly expreſſed. *The attractive Force is inverſely as the Squares of the Diſtances from the attracting Body.*

*M.* This is ſhort indeed, and plain too, when one conſiders the Examples.——

*P.* Thus the Attraction decreaſes, as the Diſtance of the Sun from the Earth is increaſed. Let us conſider next how it will be increaſed, notwithſtanding the Sun always appears of the ſame Magnitude whatever his Diſtance be: For as the Attraction grows leſs in the one Reſpect, it grows greater in the other.

*M.* Pray ſhew me how that is.

*P.* If the Sun were at twice the Diſtance, his Diameter muſt be twice as big, that it may appear but equally large to us: As a *Poſe*, or *Tree*, that it may appear to the Eye at

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at twice the Distance as high as another at once the Distance, must in reality be twice as long.

*M.* It must be so according to common Sense, and by an easy Proposition in the *Elements* of *Euclid.*

*P.* Therefore at twice the Distance the Sun's *Disk*, or Surface, must in reality be four times as large, as at once the Distance, that he may appear to the Eye but equally big.

*M.* This I think I likewise understand: For a Square whose Side is two Feet, is four times as large as another whose Side is but one Foot.

*P.* Right. Hence the Sun at twice the Distance must have eight Times the Quantity of Matter in him, to appear equally large to our Eye, he would need at but once the Distance: For a Cube whose Side is two Feet, or a Sphere whose Diameter is two Feet, is eight times as big as another whose Side, or Diameter, is but one Foot.

*M.* It is so indeed.

*P.* And by the same sort of reasoning, going on with the Steps accurately, you will find that the Sun at thrice the Distance must have twenty-seven times the Quantity of Matter in him, to appear of an equal Diameter to the Eye, that he would require once the Di-

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ſtance. And at four times the Diſtance, he muſt have ſixty-four times the Quantity of Matter in him: And ſo on.

*M.* I ſee already that theſe are but Repetitions of the firſt Argument, on the Suppoſition of different Diſtances of the Sun.

*P.* That is to ſay then, the Quantity of Matter in the Sun muſt be as the Cubes of the Diſtances we ſuppoſe him to be at from us.

*M.* Becauſe his Diameter is increaſed with his Diſtance; and his Matter with the Cubes of his Diameter?

*P.* Right.

*M.* What do you infer from all this?

*P.* At twice the Diſtance the Sun will attract four times leſs upon the account of his double Diſtance; but then he will attract eight times more upon the Account of his octuple Matter: That is, in effect, he will attract twice as ſtrongly as at once the Diſtance.

*M.* You will leave me behind, if you go on ſo faſt with your Argument.

*P.* Take it thus then. An equal Sun at twice the Diſtance would attract but with a fourth part of the Strength of our Sun at half the Diſtance, being twice as remote from us: But that he may appear of an equal Bigneſs to us with our Sun, he muſt have eight times the Quantity of Matter in him; and on that

that account must attract eight times more than this fourth Part: That is, he will attract twice as forcibly as at once the Distance. Seventh Conference.

*M.* I understand it now: His Distance lessens his Attraction, but his Quantity of Matter (growing faster than his Distance) increases it more than it is lessened.

*P.* It is so: And by the same Argument repeated, you will perceive that, at thrice the Distance, he will attract thrice as strongly; and at four times the Distance, four times as strongly as when we suppose him at once the Distance.

*M.* It will indeed follow.

*P.* All this is thus comprised in few Words. Since the Attraction of the Sun decreases inversely as the Squares of his Distance, but increases directly as the Cubes of his Distance; absolutely speaking it will be increased as his Distance directly. Thus if his Distance be 20000 Semi-diameters of the Earth from us, he will attract the Earth twice as forcibly as if it were but 10000 Semi-diameters: and if it be but 30000 Semi-diameters, thrice as forcibly: And so on.

C. *M.* You have given me a good deal of Light into this Matter, in a short Time: And from this I see; the Attraction of the Earth

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remaining ſtill the ſame, whatever the Sun's Diſtance be; the farther we ſuppoſe the Sun removed from the Earth, the nearer this *Limit of equal Attraction* will approach to the Earth; and the leſs we ſuppoſe his Diſtance from us, the farther *that Limit* will recede from it: The contrary of which I ſhould have inferred, had I been left to my ſelf.

*P.* You may likewiſe be ſatisfied of this from another Conſideration: For the greater the Sun's Diſtance from the Earth is, the larger its annual Orbit muſt be, as having a larger Radius; and the larger the Circle is, which is run over by the Earth in the ſame Time, the greater the Earth's centrifugal Force muſt be: The centrifugal Force in this Caſe increaſing directly with the Radius, or Diſtance of the revolving Body.

*M.* I ſee it plainly: And the greater the Earth's centrifugal Force is, the ſtronger the Sun's Attraction upon it muſt be, to keep it from flying off; and the ſtronger the Sun's attractive Force is, the nearer the Point, where the Earth's Force and his would balance each other, muſt approach to the Earth. So that I am ſatisfied now upon a double account that this is ſo. But pray might not *this Limit* be determined, according to any particular Diſtance the Sun were ſuppoſed to be at from the Earth?

*P.* It

*P.* It might with no great Difficulty.

*M.* Then I think it would be very agreeable to assign that *Boundary*, beyond which our Moon could not roll. We should thus see, upon the Supposition of any particular Distance, how nearly she were hemmed in; or if there were room for another Satellite, to revolve without her. I should even think that assigning this Boundary might be of use to help to determine the Sun's real Distance from us; in case, on the common Supposition, *it* were found to be so near the Moon's Orbit, that the Sun could not be farther removed from us, without *this Limit*'s encroaching on the Space in which the Moon were to revolve.

*P.* Here we must proceed by degrees, *Matho*; for though what we have hitherto said seems plain to you and me, yet it will not be easily allowed that the Moon's Motion would be disturbed, though the *Limit* of *equal Attraction* between the Sun and Earth fell within her Orbit.

*M.* Would the Moon revolve as a Satellite about the Earth, if she were more attracted by the Sun than by the Earth in the interior part of her Orbit?

*P.* This Particular of disturbing the Motion of the Moon is explained in a different manner. There is an *Axiom*, or *Propositi-*

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*on* in Philoſophy, which ſhews, we are told, that the Moon's Courſe might be preſerved regular about the Earth, though ſhe were a thouſand Times more attracted towards the Sun than to the Earth *.

*M.* A thouſand Times! Pray what is the Propoſition?

*P.* It is this; *If Forces in parallel Directions act equally on all the Bodies of any Syſtem, their relative Motions cannot thereby be diſturbed.*

*M.* I remember you mentioned ſomething like this Axiom before, when you ſhewed me the Difference between *abſolute* and *relative Motion*; and then I thought I ſaw in what Senſe it was true: But as it is applied here I do not ſee the Force of it, and think it is ſtrained too far.

*P.* How did you underſtand it then?

*M.* I ſuppoſe the Axiom was to be ſo underſtood, that the *Parallel Forces* impreſſed on the ſeveral Bodies of the Syſtem were not to deſtroy the particular Forces, whereby thoſe Bodies moved relatively among themſelves; Or, that all the Bodies of the Syſtem yielded equally to, and were equally carried along (in the immenſe Space ſuppoſe) by the paral-

* See the Hiſtory of the Works of the Learned, for *October* 1738. Art. XXX. Pag. 269.

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lel Forces. And on these Conditions the Sense of the Axiom seems plain and obvious: But in the present Case, where the *Earth* and *Moon* revolve about the Sun as a Center, the Circumstances are very different; therefore the Axiom seems less applicable. The Sun in the Conjunction of the Moon attracts her own way, and the Earth (which doth not yield to the Sun's Force, so as to draw nearer him) attracts her the other: And in this Case, if the Sun's Force in drawing the Moon down towards himself were a thousand times greater than the Earth's in drawing her the contrary way; or if the *first* were but barely equal to the *last*; then the Axiom, instead of shewing that the relative Motions of the System could not thereby be disturbed, seems to me to shew that the *System itself* should be quite dissolved.



CI. *P.* But here you leave out the principal Condition, which is, *That the Earth be equally attracted with the Moon.*

*M.* That Condition, as I take it, does not shew the Thing intended. For the Earth's centrifugal Force hinders it from drawing nearer the Sun, or being carried along with his Attraction, how great soever it may be supposed to be: But when the Moon descends to her

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her Conjunction, her centrifugal Force in her own Orbit rather conſpires with the ſuperior Force of the Sun. And though we ſhould ſuppoſe that the *Impreſſion* we ſpoke of before (which is ſtill made on the Moon parallel to the Earth's circular Motion) hindered her from deſcending to the Sun; yet it could never aſſiſt her in riſing after her Conjunction through the oppoſite part of her Orbit; ſince this Impreſſion would carry her in a concentrical Circle to the Earth's Orbit, or bend her Courſe the contrary way. Of the *four Forces* therefore, which act conſtantly upon her, *three* reſiſt her riſing after the Conjunction; *viz.* the Sun's attractive Force, the Force impreſſed always parallel to the Earth's Motion, and her centrifugal Force in her own Orbit: Whence we have nothing left to make her mount towards the Earth's Orbit, but the weaker Attraction of the Earth itſelf. It is here I conceive where the Difficulty lyes; and in turning up again it appears to me the prevalent Attraction of the Earth is neceſſary: Otherwiſe ſhe would move from her Conjunction (not indeed down to the Sun) but forward in a ſeparate Orbit of her own, incurvated to the Sun, and bent from the Earth, which muſt ſeparate her from rolling about the Earth as a Satellite.——

*P.* Have

*P.* Have you done?

*M.* I may not perhaps have spoke so intelligibly as I could wish; but what I mean in short is this. The Orbit of the Earth is every where equally distant from the Sun; therefore the Earth never yields to the Sun's Attraction: For as its Gravitation would carry it down to the Sun, and its projectile Force would carry it to a greater distance from him; by a Composition of both Forces it keeps still at an equal Distance from him. But the Moon sometimes descends nearer the Sun, and after that ascends to a greater Distance from him: And this rising to a greater Distance is not relative but absolute. For when the Distance between two Bodies is changed, one of the two at least must have a *real* and *absolute Motion*; and it will not be said, I believe, that this *real Motion* belongs to the Sun. Now when the Moon moves absolutely to a greater Distance from the Sun, it must be by moving against the whole Force of his stronger Attraction, by means of the weaker Force of the Earth; which appears to me really impossible. And if this be so, it must be a false Explication of the Axiom, which makes it contradict a plain and self-evident Truth, *viz. When two unequal Forces are at once impressed on the same Body in contrary Directions, it must yield to*

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*to the ſtronger and not to the weaker.*

*P.* I both underſtand what you ſaid before, and what you ſay now, very well; nor do I ſee at preſent what can be reply'd.

*M.* It appears to me likewiſe, that we may come to the Solution of this Difficulty very eaſily thus. Imagine the Earth to ſtand ſtill in the ſame Point of its Orbit, hindered by ſome Power or other from yielding to the attractive Force of the Sun, while the Moon performed her menſtrual Courſe about it: And if the Attraction of the Sun were ſtronger than that of the Earth, ſhe muſt yield to that prevalent Force, and be carried off from the Earth. Now when the Earth has its projectile Force impreſſed upon it, no new Force is impreſſed upon the Moon, except that in a parallel Direction always to the Orbit of the Earth: And *this*, as has been obſerved, could never help to carry her upward from the Conjunction; but would rather bend her Courſe concentrical to the Earth's.

CII. *P.* Your Reaſoning becomes clear and intelligible, *Matho*, by arguing thus from the Point of the Moon's Conjunction: But if the Limit of equal Attraction between the Earth and Sun lay within the Moon's Orbit, it ſeems no leſs true, that ſhe would be drawn

out

out of her Course from any Point in the interior half of her Orbit. Seventh Conference.

*M.* Pray make me understand how this could be.

*P.* If this Limit were at the Distance of 40 Semi-diameters of the Earth (*ex. gr.*) from its Center, that is, 20 Semi-diameters within the Orbit of the Moon; imagine a Semi-circle concentrical to the interior half of her Orbit, described through this Point. And since the Attraction of the Sun is nearly as great as the Earth's Orbit, as at the Point of the Moon's Conjunction, this Semi-circle will shew every where the Limit of equal Attraction between the Sun and Earth; and therefore it shews that the Moon is within the stronger Attraction of the Sun through the whole interior half of her Orbit.

*M.* It is very plain. I conceived the Limit of equal Attraction confined to one Point; namely, in a Line reaching from the Center of the Earth to the Center of the Sun: But this Semi-circle shews me the whole Bounds of the Sphere of the Earth's Attraction, with respect to the Sun. For if the Semi-circle were turned round on its Radius which passes through the Center of the Earth, it would form an Hemisphere circumscribing the Earth's Attraction, and dividing it from the Sun's superior Force.

*P.* This

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*P.* This ſeems to me a natural Conception of the Caſe.

*M.* If then we have reaſoned rightly hitherto, this Condition, I think, ought to be added to the *Axiom* above; *viz.* Not only that the parallel Forces act equally on all the Bodies of the Syſtem; but that the whole Syſtem yield to theſe Forces, or be equably carried along by them. Otherwiſe we ſhall ſo explain *this Propoſition*, as to make it contradict the ſelf-evident Truth I mentioned juſt now.

*P.* Theſe are the Conditions on which you ſaid the Senſe of the Axiom was plain and obvious. Now it would much conduce to the clearing up of this whole Affair, if you could ſhew by plain Examples that the Axiom holds on theſe Conditions, and cannot hold without them.

*M.* Let me take a little Time to digeſt my Conceptions.

*P.* Take your own Time.——

*M.* Let us firſt ſuppoſe that two Bodies were carried along in a free Space, with equal Celerity, and in the ſame Direction, by the parallel Forces. They would then be relatively at reſt, or they would not change Diſtance with reſpect to each other: And in this Caſe it is eaſy to ſee that a ſmall Force might make

them approach to, or recede from one another. Let them be ten Feet asunder, and carried down at the rate of ten Feet in a Minute; and let the *last*, or *greatest* of the two, attract that which is before it, at the rate of one Foot in a Minute. I choose these small Numbers and Quantities, that the Imagination may not be perplexed with Distances and Forces almost incomprehensible.

*P.* You do right to make the Supposition as simple as possible: That is the readiest way to come at the Truth.

*M.* In these Circumstances the *two Bodies* would come together in ten Minutes, after the *uppermost* or *last* had moved an hundred Feet, and the *undermost* ninety: For here in every Minute the Motion of the *under Body* is retarded one Foot by the Attraction of the *upper*; and in effect it is the *upper Body* which approaches the *lower*, or runs over the whole relative Distance between them; Or it is the *upper Body* that descends with the parallel Force in this Case, and not the *under Body* that mounts against it. That I take to be an absolute Impossibility. But now if we should suppose the *upper Body* to be detained in any manner, or hindered from being carried along by this parallel Impression, while the *lesser* and *lower Body* were left to follow its Impulse; this last would

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would then be carried down from the other at the rate of nine Feet in a Minute; which is the Difference betwen the Effects of the two Forces.

*P.* All this is undeniable.

*M.* Let us farther ſuppoſe while the *upper Body* remains fixed and immoveable, that the *under Body*, ten Feet diſtant from it, receives a tangential Impulſe, in ſuch Proportion as would make it revolve about the other in a Circle, if the parallel Forces did not act? and it is equally undeniable that this Body could not riſe againſt the parallel Force, which is ten Times ſtronger than *that* wherewith it is attracted to a Center. For the whole Force of the Attraction is not oppoſed to this ten-fold greater Force, but in one Point.

*P.* If *one Degree* of Force overcome *ten*, certainly nine of them muſt be overcome by nothing.

*M.* Laſtly, If we ſhould now ſuppoſe the *upper Body* not fixed, but moving along by the parallel Impreſſion, the *under Body* receiving the tangential Impulſe, as before, would then revolve about it; not by riſing abſolutely againſt a greater Force, but by the other Body's falling down, and its getting relatively to the upper Side.

*P.* It appears to me, *Matho*, you have purſued

purſued your Suppoſition fairly enough, and ſhewn what you undertook. Seventh Conference.

CIII. *M.* It ſhews, if I have repreſented Things right, that when both the Bodies are carried equally along by the parallel Forces, their relative Motions are not thereby diſturbed; but that without this Condition the Syſtem itſelf is diſſolved. For where the *upper Body* was ſuppoſed not to be carried along, the *under Body* was carried off from it: Nor could *this laſt* revolve about it then in a Circle, though impelled by a projectile Force. And this is applicable to the Moon, if the Limit of equal Attraction between the Sun and Earth fell within her Orbit. She would be carried off by the ſtronger Force of the Sun in every Conjunction: Unleſs indeed we ſhould have Recourſe to the *Interpoſition of the Deity* to prevent this. Which if it could be ſhewn neceſſary I ſhould not be againſt: But for one to have Recourſe to ſuch Interpoſition here, though it were neceſſary, would be to give up the Axiom.

*P.* More, I think, needs not be ſaid on this Head.

*M.* We may vary the Conditions of the Suppoſition a little, till we come to the Circumſtances in which only the Moon, as I con-

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ceive, could revolve about the Earth.—— Thus, while the parallel Forces carry along the two Bodies at the Rate of ten Feet in a Minute, we may ſuppoſe that the *upper Body* attracts the *lower* juſt ſo much in that Time: In which Caſe the *lower Body* would move neither Way, but remain abſolutely at Reſt; and the *upper* would run over the whole Diſtance between them. If here the *lower Body* received a projectile Impulſe in due Proportion, it would revolve about the *other*, not by riſing abſolutely againſt an equal Force; but by the *upper Body*'s being carried down, and coming in below it. But if we ſhould ſuppoſe the *upper Body* fixed, ſo as not to yield to the parallel Force, the *other* without a tangential Impulſe would remain ſuſpended between equal Forces, at the Diſtance of ten Feet ſtill from the *greater*: And if this *leſſer Body* received a tangential Impulſe, it would then be thrown off at a Side from the *greater*; but could not revolve about it. And this would be the Caſe between the Earth and Moon, if the Limit of equal Attraction fell upon the Moon's Orbit; or if ſhe were equally attracted by the Earth on the one Side, and the Sun on the other.

*P.* I have nothing to reply; every Thing ſeems as plain here as in the former Caſe.—

*M.* We

*M.* We may in the last Place suppose that the parallel Forces impelled the two Bodies at the Rate of but one Foot in a Minute, while the *upper Body* attracted the *lower* at the Rate of nine Feet in that Time. And in these Circumstances the *upper Body* would only move one Foot by the Force of the parallel Impression, while the *lesser* moved nine Feet against it: But here it moves by the stronger Force, and the whole System yields to the parallel Impression a Foot in a Minute. And though now the Descent of the *greater Body* were impeded, the *under Body* by this stronger Attraction would nevertheless come up to it. If then *this last* received a projectile Impulse, to give it a centrifugal Tendency, it would revolve about the *other* as a central Body, being within the Sphere of its more powerful Attraction, and having no where in its Revolution a superior Force to overcome.—Nay, though now both Bodies should receive an Impulse always in parallel Directions, and at right Angles to the first parallel Forces; or though the first parallel Forces now tended to a distant Center, so that *this System* revolved about that distant Center; the *lesser* of the two Bodies would still perform its Revolutions about the *greater*; all these different Impressions being still regularly maintained by some Seventh Conference.

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*powerful* and *mighty Hand.* Which is exactly the Case of the Moon, more powerfully attracted by the Earth than by the Sun; or when the Limit of their equal Attraction falls without her Orbit.

*P.* To use your own Words, *Matho*, the same Things are so often to be named, and the Conditions so often to be repeated, that there is some Difficulty in following the different Steps of your several Suppositions: But when they are distinctly conceived, the Reasoning seems very close. From the *first Supposition* it appears that the Moon could not revolve about the Earth, if the Limit of equal Attraction between it and the Sun fell within her Orbit; and the *second* shews that it would not be enough to make her revolve, though that Limit coincided with her Orbit. Whence it must fall without the Space she revolves in, according to the Conditions of the third Supposition. But it is certainly Time now to leave this Subject, since we have nothing more to say about it.

*M.* Permit me first to ask you a few Questions.——

CIV. Pray tell me, does any of the Distances assigned to the Sun bring *this Limit* of equal Attraction between the Earth and him, within the Orbit of the Moon?

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*P.* If the Sun's Distance from us were 34000 Semi-diameters of the Earth, as some have supposed; that *Limit* would fall, at a middle Rate, 26, and sometimes 29, Semi-diameters of the Earth, within the Moon's Orbit; that is, about 104000, or 116000 Miles nearer the Earth than the Moon.

*M.* Then that Distance must certainly be too great; for it is inconceivable that such a large Portion of the Moon's Orbit should lye within the Regions of the Sun's stronger Attraction.

*P.* The whole interior Half of her Orbit, *Matho*, would then lye a great Way within his stronger Attraction; as has already been observed: In which Case, the Earth's Force on the Moon would sometimes be little more than a fourth Part of the Sun's Force upon her. And here it is very remarkable, that the weaker the Earth's Force were on the Moon in Comparison of the Sun's, the more equal the Sun's Force would be on both the Earth and Moon, and the Directions, in which it acted on both, more nearly parallel: So that the Conditions required, according to the aforesaid Explication of the Axiom, for disturbing the Moon's Motion least, (*viz.* That the Sun attract both the Earth and her equally, and in parallel Directions,) would be attend-

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ed with another Condition, which would diſſolve it quite; namely, a great Exceſs of the Sun's Force above the Earth's upon her. And theſe inconſiſtent Conditions muſt always encreaſe together.

*M.* Let me conſider this a little,——The greater the Sun's Diſtance from us is, the more equal his Force upon the Earth and Moon will be; becauſe the Difference between the Squares of the Diſtances of the Earth and Moon from him muſt be the leſs. And likewiſe the greater his Diſtance is, he muſt attract both the more nearly in parallel Directions. But the greater his Diſtance is, the nearer the Limit of equal Attraction betwixt him and the Earth muſt approach to the Earth; or, the leſs the Earth's Force on the Moon muſt be in Reſpect of his.——I ſee it very plainly, *Philon*; it is as you ſay. *Theſe inconſiſtent Conditions* muſt encreaſe together. And this Conſideration ſeems to make the Explication of the Axiom ſomewhat irreconcileable to itſelf: For ſurely it could not be pretended that the Motion of the Moon would be more irregular, if ſhe were more attracted by the Earth than by the Sun; and yet the greater the Earth's Attraction were upon her, the leſs equal ſhould the Sun's Action be on both her and the Earth. ——Pray inform me next, if the *Limit of equal*

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*equal Attraction* between the Sun and *Jupiter*, or between the Sun and *Saturn*, fell within the Orbits of their Satellites; could that remarkable Proportion be then observed between the Cubes of the Distances and the Squares of the periodical Times of those Satellites?

*P.* It could not; for that Proportion is a necessary Consequence of those Satellites being attracted to the Centers of their respective Primaries, by the same Law as the Primaries are attracted to the Center of the Sun: That is, that their Gravitation to their Primaries be increased, as the Squares of their Distances from these Primaries decrease. Which Law could not obtain, if they gravitated more to the Sun than to their primary Planets.

*M.* It seems then, what could not agree to the Systems of *Jupiter*, or *Saturn*, could as little agree to the System of the Earth and Moon. For, tell me, if 3 or 4 Moons revolved about our Earth, would not they observe the same Proportion between the Cubes of their Distances and Squares of their periodick Times.

*P.* They would observe the same Proportion; for they would gravitate the same Way to the Earth, as the Satellites of *Jupiter* or *Saturn* do to those Planets. And it is observable here, *Matho*, that the *great Author*,

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to whom we owe the Diſcovery and whole Theory of Gravitation, makes the ſame Supposition of more Moons revolving about our Earth; and concludes they would all obſerve this Proportion, and therefore the fundamental Law of Gravitation, where the attracting Forces are reciprocally as the Squares of the Diſtances from the attracting Body *.

*M.* But they could not obſerve that Proportion, nor this fundamental Law, if they were a thouſand Times, or twice, or but more attracted to the Sun, than to the Earth?

*P.* They could not then ſo much as revolve about the Earth, if we have reaſoned rightly on this Point before.——

*M.* Abſolutely ſpeaking, according to this Senſe of the *Axiom*, it is poſſible that the Moon might revolve about the Earth, though the Limit of equal Attraction between the Sun and it approached to it's very Surface?

*P.* That is too extravagant a Suppoſition, *Matho*, and makes the Earth's Attraction of little or no Uſe at all to the Moon's revolving about it.

* Si Lunæ plures circum terram revolverentur, perinde ac fit in Syſtemate *Saturni* vel *Jovis:* harum tempora periodica (per argumentum inductionis) obſervarent legem Planetarum à *Keplero* detectam, et propterea harum vires centripetæ forent reciprocè ut quadrata diſtantiarum à centro terræ. *Philoſoph. Nat. Princip. Math.* Lib. 3. Schol. Prop. 4.

*M.* Yet

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*M.* Yet it seems a genuine Consequence of what is asserted: For why should any Regard be had to the Earth's Attraction, if the Moon might revolve about it, and yet gravitate a thousand Times more to the Sun? Or is it impossible that the Sun should attract at the Surface of the Earth, as strongly as the Earth itself?

*P.* It is possible more Ways than one: But in that Case all Bodies on the Surface of the Earth would be loose, or in Suspense between two equal and opposite Attractions, and could not therefore revolve with the Earth on its Axis: Their centrifugal Force would throw them off towards the Sun.

*M.* Might not the Moon revolve about the Earth at four or five Times the present Distance from it; provided the Sun attracted the Earth and her equally?

*P.* Pray when will you have done with your Questions?

*M.* Very soon: Answer this.

*P.* If the Sun were at such a Distance as to attract the Earth and Moon equally, in that Case the Limit of equal Attraction would draw nearer the Center of the Earth, or fall more than 200 of its Semi-diameters within the Orbit of the Moon, when so far removed.

*M.* These

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*M.* Theſe ſeveral Conſequences ought, I think, to have been conſidered.——You ſaid that the Moon, by her Gravitation to the Center of the Earth would fall 16 or 17 Feet towards it in a Minute?

*P.* So much ſhe is attracted from the Direction of her projectile Force in that Time; as the ſame *great Author* has ſhewn.

*M.* And that on theſe Principles the Time of her falling quite down to the Earth is eaſily computed?

*P.* With no great Difficulty.

*M.* Now I have done with my Queſtions, and ſhall ſtick to the firſt Reaſon why the Action of the Sun over the whole Syſtem does not draw the Satellites from their primary Planets; at leaſt till I ſee ſtronger Arguments againſt it.

*P.* The Condition you add is reaſonable.

*M.* At the ſame Time though I think it ſhould ſtumble every Body, and they muſt deſpair of ever underſtanding theſe Motions, if the Explication of any *Axiom* ſuſpended the plain and ſelf-evident Truth I mentioned before; or ſhewed that, when two unequal Forces act at once on the ſame Body in contrary Directions, it may yield to the weaker in Oppoſition to the ſtronger.

*P.* As

*P.* As long as that Truth lyes in the Way, it will be the more difficult to assign any other Reason than we have done, why the *secondary Planets* are not carried off from their *Primaries* by the Action of the Sun.——

*M.* Do you want to be relieved, *Philon?*

*P.* Very much: You ask Question after Question without Mercy.

*M.* I am glad of this Confession: My Imagination is a little fatigued with these Niceties, and not strong enough to enter on a new Subject; though I have not half done with the Particulars I designed to ask. Therefore I shall be with you again very soon.

*P.* Then we must agree for the future how long we are to discourse, and not talk on at your Discretion.

*M.* We may think of that hereafter.

THE

# Eighth CONFERENCE.

Matho *desires to know why the Secondary Planets might not have revolved separately about the Sun, as the immediate Center of their Motion? If the Distance of the Satellites from their Primaries had been greater or less, what must the Consequences have been? That there may be more Bodies in the solar System than are discoverable by us. In what Proportion the centripetal Force is increased or diminished, as the Planet is nearer to, or more remote from the Sun. From what Causes the centrifugal Force becomes greater or less. It is shewn necessary, by bringing the centripetal and centrifugal Forces to an Equilibrium, that the Cubes of the Distances of the Planets from the Sun must be as the Squares of their Periodical Times. And contrarily, as this Proportion holds in fact, from thence it is shewn, that the centrifugal, and therefore the centripetal Force, must be inversely as the Squares of the Planets Distances from the Sun.*

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CV. *P.* I FIND, *Matho*, you keep your Word punctually; wherefore let us now settle how long we are to discourse.

*M.* I have observed, *Philon*, when a Man is every now and then looking at his Watch, to see whether the Hour be near, or past, his Head is more set on what he is to do, than what he is doing: So pray let us begin without any such Condition.

*P.* You will have every Thing your own way.

*M.* My third Difficulty, as you may remember, was, Why the Secondary Planets should not revolve directly about the Sun, rather than about other Planets, which revolve about him? For there is a Simplicity in all the Works of Nature, though still pregnant with Variety of Effects; so that there must be some weighty Reason for this extraordinary Complication, and compounding of circular Motions with circular Motions.

*P.* It is very true; this could not be done without Choice and Design. The *Great Architect of Nature* might have disposed those Bodies in other different manners; but possibly in none either more wonderful, or more useful. The Power and Knowledge displayed raises our Wonder, you find, to the greatest

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eſt Height; the Mind ſinks under the Variety; for ſtretching to get a full View, it is ſoon forced to ſlacken in the Attempt: And as to the Uſefulneſs, it is ſurely the moſt extenſive we could conceive.

*M.* I know from Experience how ſoon the Mind is forced to ſlacken; but have no Notion of the extenſive Uſefulneſs of this complex Machination, which is the main thing I want to be informed in.

*P.* You will diſcover this yourſelf as we go on: In the mean time it is eaſy to perceive thus much of the Deſign. The Sun, as was obſerved before, is the *Fountain of Heat and Light* to the whole Syſtem: Upon this account the Poets ſometimes called him the *Eye of the World*; and for the ſame Reaſon you inferred that he was to be a Body of exceeding Magnitude and Grandeur, in reſpect of the Planets that roll round him.

*M.* I do remember it.

*P.* Yet it was not poſſible that all the Parts of the Syſtem; as well the remoteſt, as thoſe that lye neareſt to him; ſhould enjoy this Advantage of his Heat and Light equally.

*M.* It was not: For as the Center of the Syſtem was the moſt proper Place for diſpenſing theſe with the greateſt Equality, it neceſſarily follows that, while the Diſtance from the

the Center is increased, the Influence of his Rays must be less perceived. 

*P.* Wherefore, though *Mercury*, which is next to the Sun, and perhaps *Venus* the second from him, sufficiently enjoy this kindly Influence from his direct Rays; yet our *Earth*, which lyes at a greater Distance, hath a Moon to attend it: And it is by her throwing back on the Earth his reflected Splendor, that we enjoy the Light of the Sun more ways than one; and our Nights, especially in the Winter Season, borrow a secondary sort of Day from the Orb of the Moon.

*M.* I have often indeed admired the Difference of the Winter and Summer *full Moons:* When the Nights are long, the full Moon mounts high in the Heavens, and sheds a strong Light; but in the Summer Months she creeps dimly among the Clouds and Vapours near the Horizon: The Reason of which, I think, is not difficult to be found out.

*P.* It is rather necessary it should be so; but to proceed: As *Jupiter* is much farther removed from the *Focus* of the System (if we may so call the Sun) four Moons roll about him, which, by their quick Revolutions, variously illuminate the Hemisphere of that Planet turned from the Solar Rays, and pleasantly

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ſantly diverſify his Nights, though otherwiſe remarkably ſhort. For (if we might call the Revolutions of thoſe Satellites by the Name of Months, as we do thoſe of our Moon) ſome of the Months in *Jupiter* are not ſo long as two Days with us, conſiſting of but about forty-two Hours; others of them are leſs than four of our Days, and the longeſt of them, which contains forty of the Days in *Jupiter*, is hardly equal to ſeventeen Days with us. Whence ſome or other of theſe Moons muſt either be in the Oppoſition, and ſhine with full Luſtre, or in the Conjunction, or in the Quadratures, almoſt every Night. Beſides, theſe Moons, by their *manifold Eclipſes* (while they frequently dip into the Shadow of their *Primary*, often obſcure the whole Body of the Sun, and ſometimes intercept the Light of one another) afford a moſt entertaining Proſpect, and inſtructive Phænomena to the Inhabitants of that Planet, if any ſuch there be.

*M.* This is really a noble, and (if I may ſo ſay) an expenſive Contrivance for reflecting the Solar Rays on all the Parts of this large Planet: Though he does not enjoy ſo ſtrong a Light as our Earth; yet I perceive he hath a far more delightful Variety of Splendor.

*P.* This

*P.* This Apparatus, *Matho*, for reflecting the Light on all the Parts of the Primary Planet, is the more curious, if we consider that at great Distances from *Jupiter*'s Equator the lower Moons cannot be seen; the Curvature of his Surface intercepting them from the Spectator's Eye: Therefore the other Moons are raised above these, to give Light (as it would appear) to those in greater Latitudes.

*M.* That seems really to be the Design.

CVI. *P.* The Contrivance is still heightened when we come to *Saturn*, the remotest of the Planets. He hath five Moons constantly rolling round him, which variously throw in the borrowed Light of the Sun on his distant Orb: And many suppose, because of the large Interval between the fourth and fifth, that there is a *sixth* revolving there; though the Telescope has not yet been able to discover it. These, especially the four innermost, resemble *Jupiter*'s Moons in the Smallness of their Distance from their Primary, and Quickness of their Revolutions about it: Therefore they diversify *Saturn*'s Nights (which in all Probability are likewise but short) with various and beautiful Appearances of the same Nature as in *Jupiter*. But besides all this, he is surrounded

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rounded with that ſublime and ſtupendous *Arch*, which we mentioned elſewhere; and to which nothing is found equal, or like, in all Nature, ſo far as Mortals hitherto know. What a grand and noble Sight muſt it be, to behold in the Night time, ſuch a lofty reſplendent Arch, riſing from the Horizon on each Side, and ſtretching up to the Heavens; which, as the Diſtance from it encreaſes, ſeems the more auguſt and ſtately! This prodigious *Annulus* itſelf probably turns round on its Axis; for it is reaſonable to ſuppoſe, that no Body in Nature fitted for ſuch a Motion, is without it. Thus the Shadow of the interior Planet, which always falls on one of the Sides of this Ring, when the Sun has a Declination to either Tropick, muſt ſoon be removed, and the Light of the Sun reſtor'd.

*M.* Let me aſk you, Does the Plane of this *Ring* fall in with *Saturn*'s Equator?

*P.* It does.

*M.* Then I eaſily conceive that the Shadow of *Saturn* muſt be projected on that Side of it, towards which the Sun declines. Pray go on. Theſe Appearances are new and ſingular, as if one were inventing ſomething to amuſe the Fancy.

*P.* It is not eaſy to reckon up the ſeveral different Appearances which this mighty vault-

ed

ed Body must make to the different Parts of the Planet; or rather to a Spectator there residing. At some Times of *Saturn*'s Year, and in certain Latitudes from his Equator, it eclipses the Sun every Noon, as he declines more or less to the opposite Side. And though the Duration of these Eclipses be still varying, yet they can never last long, if the diurnal Rotation of the Planet on its Axis be as quick as that of *Jupiter*. Eighth Conference.

*M.* Pray how far is the inner Edge of the Ring distant from the Body of *Saturn*?

*P.* About six or seven times the Semi-diameter of our Earth; and they reckon the Ring itself to be as broad.

*M.* Then I conceive, methinks, since the Plane of the *Ring* falls in with *Saturn*'s Equator, and since there is so large a Space open between it and the Body of the Planet, that in some Places where it is Winter, and the Sun declines to the opposite Tropick, he must appear under the *Ring* at Mid-day, shining through between it and the Body of the Planet: And contrarily, in Places more remote from the Equator, the upper Part of the Ring must eclipse him at Noon-day: And that these *meridian Splendors* and *Eclipses* must still extend farther towards either Pole, the farther the Sun declines to the opposite

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Side. For if the Arch of a Bridge lay South and North, the Light below and Shadow above must become shorter or longer, as the Sun rose higher in the Morning, or descended lower towards the West in the Evening.

*P.* This is indeed finely imagined!

*M.* Since these things are so, I am entirely for a diurnal Rotation of *Saturn* on his Axis; otherwise these Eclipses would last, I presume, for some of our Years.——But pray what can the Design of this extraordinary Contrivance be?

*P.* Alas! *Matho*, this is what I am not able to tell you. The greatest Men have hardly attempted this in Conjecture; and those, who have ventured to make Suppositions, have talked rather as if they had been thinking of the Ruins of some decayed Fabrick, than the Works of an *Almighty Being*. From all Appearances it seems to be a Work still in Repair, and answering still the same Purpose for which it was originally contrived. Thus much only I think we may venture to say, That it was originally designed for some greater Purpose than barely to reflect the borrowed Light of the Sun on the Globe it surrounds: Since during one half of the Year in *Saturn* it intercepts as much Light, as it reflects the other. And certainly the Purpose it serves for, whatever that may

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may be, cannot be less noble, than the Structure itself is strange and singular.——

*M.* How comes it then, *Philon*, that we should so ardently desire the Knowledge of Things which are without our Reach? Are those Desires unreasonable? or is the Accomplishment of them only impossible? If the Desires themselves are unreasonable, why should they be so strong? If they are not; why should it be impossible to gratify them?

*P.* You asked this before, as a *Question*, *Matho*; and now you urge it as an *Objection*. In the Pursuit of Knowledge we should proceed by Degrees and with Attention: Every Thing in Time will appear consistent: We cannot discover the Reasons of Things by Precipitance and Impatience. We know not all the Wonders in our own Bodies, and therefore ought to be the less impatient, that we know not all Wonders in the Universe round us. You inferred perfectly well before, *That we can have no rational Desires, but what were designed to be gratified.* The Methods of Sense are not accommodated to the finishing our Enquiries, or the full Attainment of Knowledge. An Eternity of sensitive Life would be the greatest Misery to a rational Being, and could never have been proposed by the Author of the rational Nature. An E-

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ternity of Sloth and Inactivity to an *active Nature* is no leſs abſurd. We are ſo framed as neceſſarily to have interminable Views; but have not enough conſidered what would be the conſiſtent Employment of interminable Exiſtence to a rational and active Being. The Conſideration of theſe Things would carry us a great way, and is foreign to our Purpoſe.

*M.* You affect, I perceive, to talk myſteriouſly; and for all that I underſtand ſo much of what you ſay as gives me Pleaſure: But, to leave a Subject you are unwilling to enter upon at preſent, tell me,——

CVII. If the remoter Planets had thoſe Moons to attend them, in order to compenſate their Diſtance from the Sun, by reflecting on them his borrowed Splendor; how comes it that *Mars* has none? He is more remote from the Sun than our Earth, which notwithſtanding hath an Attendant to caſt upon it this ſecondary Light.

*P.* We cannot be certain that *Mars* is without a Satellite; the Learned are rather of Opinion that he hath one, though it be not conſpicuous to the Inhabitants of our Globe, becauſe of its Smallneſs: For as *Mars* is one of the leaſt of the Primary Planets, it would be againſt the Order of Nature, if he carried

carried along with him a larger Secondary. And it is the more probable that he is not unattended, because his Distance from the *Earth* is greater than the Distance of the Earth from *Venus:* And some reasonably suppose that even *Venus* too hath a Moon attending her. So that if there be Room between the Earth and *Venus* for each to have a Satellite, without disturbing the one the other, there is still more Room between the Earth and *Mars* for this Purpose. Eighth Conference.

*M.* This Increase of Distance cannot indeed be for nothing; nor can we imagine that any of the Planets would have been set at greater Distances from the Heat and Light of the Sun, without a weighty Reason.

*P.* A Satellite of this Planet likewise must be more difficult to be observed, because the *Secondary* of a small *Primary* must revolve at a less Distance from it.

*M.* If then both *Mars* and *Venus* have Moons attending them, there will be *new Bodies* in our System.

*P.* Though as old as the System itself, they must be new to us, as *Saturn* and *Jupiter*'s Moons were, which lay hid from the Eyes of Men, through all past Ages, and must have still remained unknown, had not the happy Invention of the Telescope discovered them, not very many Years ago.

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*M.* At this rate we cannot be certain that we know all the Bodies of our own Syſtem.

*P.* Nothing that concerns the Welfare of the Syſtem depends on our Knowledge. The Ancients thought they knew all the Bodies of the Syſtem, when they reckoned but eight of ſeventeen which we know. Nevertheleſs concerning this Matter I would have you conceive thus.——The Solar Syſtem, with reſpect to us the Inhabitants of the Earth, conſiſts of thoſe Bodies which we can perceive: But if a Spectator were to be carried from one part of the Syſtem to another, he would loſe Sight of ſome Bodies that were before conſpicuous to him, and others he knew nothing of before would come in View. Thus were he placed in *Saturn*, he could perceive none of the inferior Planets, except *Jupiter*, which would appear to him ſo to move about the Sun, as *Mercury* appears to do to us; but at a ſomewhat greater Diſtance: *Jupiter*'s greateſt Elongation from the Sun appearing there to be about thirty-ſeven Degrees, and *Mercury*'s here about twenty-eight. As to *Mars*, *Venus*, or our Earth, a Spectator placed in *Saturn* could never know that there were ſuch Bodies in Nature, unleſs he chanced to eſpy them like dark Spots in the Diſk of the Sun, while they paſſed in their retrograde Motion, between that Luminary and his

his Eye ; as we sometimes perceive *Venus* and *Mercury*. And from this accidental View of such *black Points* in the midst of the Light, he could not in the least conjecture what they were ; or that they were Planets carried by the same Laws about the Sun, as *Saturn* himself is. Yet he would have a *glorious Heaven* over his Head, illuminated with five bright Moons, (or six probably) besides the wonderful *pendulous Arch* we spoke of, and the innumerable Host of fixt Stars. The surprising Phænomena of those nearer Bodies would make him look upon *Saturn* as the most delightful Seat in Nature. Nay, when the Spectator had come down so far as *Jupiter*, he could even there perceive none of the four inferior Planets, unless by the same Accident as in *Saturn*, or the Help of better Inventions than have been hitherto discovered. If we suppose him assisted with such Helps, and that he had Skill to make Observations, he might still see the *Train* he left behind him, but not the noble Appearances they made in the *upper Planet :* But this could not be a Sight for common Eyes, or for daily Use.

*M.* It must be so : For, if we may compare small Things with great, the most stately Fabricks shrink into a diminutive and confused Appearance, when we are removed but

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a few Miles from them ; and others we did not formerly attend to grow magnificent and ſtately as we draw near them.

*P.* That is the very Caſe here : *Jupiter* in the Approach would ſwell immenſely to the Eye, ſo as to make the Grandeur of *Saturn* to be quite forgot ; and beſides the *Firmament of fixt Stars* and the ſuperior Planet *Saturn*, the Spectator would here be entertained a-nights with four refulgent Moons, each appearing much larger than the Sun himſelf ; whoſe different *Phaſes*, nimble *Revolutions*, and various, as well as frequent *Eclipſes*, would continually afford him rational Amuſement.

CVIII. *M.* Pray proceed ; you carry me on delightfully through the ſeveral Parts of our Planetary World. Methinks I ſee the *Heaven* of *Jupiter*, or *Saturn*, much more beautiful than what we perceive here in a Winter Evening. Theſe radiant Moons, in the Neighbourhood of their *Primaries*, muſt engage a Spectator there more ſtrongly in the Contemplation of Celeſtial Appearances ; and in my Opinion make him more eaſily acquainted with the Laws and Principles of theſe Motions, than can be done here with us.

*P.* I am of the ſame Opinion : For having

ing a compact System of Planets so near at Hand, and residing on a larger Body, whose Semi-diameter bears a great Proportion to the Distances of these neighbouring Moons, he would have great Advantages in making Observations, and consequently in discovering the fundamental Law of Bodies revolving about a Center, by the Composition of a centripetal and projectile Force.—But if we suppose the Spectator brought down to *Mars*, the Celestial Appearances will have quite changed their Face. He would indeed perceive our Earth going before, or following after the Sun, as a Morning or Evening Star, after the same Manner as we do *Venus*; though its Elongation from the Sun would not be quite so great; and *Venus* would appear to him, as *Mercury* does to us, generally obscured, to wit, by the Neighbourhood and brighter Rays of the Sun. But for *Mercury*, he could not get a Sight of that Planet, unless he espied him by accident as a small black Speck on the Sun's Disk. And for the like Reason the learned *Gregory* supposes, that we the Inhabitants of the Earth cannot be certain, that there is not another Primary Planet inferior to *Mercury* himself, or between him and the Sun. But the Spectator in *Mars* would see the two superior Planets, *Jupiter* and *Saturn*, though without their shining

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ſhining Moons. Whence the Nights in this Planet, which are nearly of the ſame Length as ours about the Equinoxes, muſt be more dull and languiſhing than our Nights about that Time, unleſs he be accompanied by a Moon of his own. And as a Spectator *there* could not perceive our Moon with leſs Difficulty than the celebrated *Caſſini* got once or twice a Glimpſe of *that* of *Venus*; ſo it muſt be ſtill more difficult for a Spectator *here* to get a View of his Moon, as being leſs, and rolling at a leſs Diſtance from him.——Thus you ſee, *Matho*, that the ſame Syſtem muſt appear to conſiſt of very different Bodies, when a Spectator is ſuppoſed to be carried up and down through the ſeveral Parts of it. It is no Argument therefore that Bodies which make for the Symmetry and Order of the Syſtem are wanting, becauſe we do not perceive them: It is rather probable that there are ſeveral Planets, either primary or ſecondary, which the Induſtry of Mortals hath not yet diſcovered; nor perhaps ever will. Who before *Gallilæo* could have ſuſpected that *Jupiter* had been ſo nobly attended? Or, who would have believed that *Saturn* was accompanied by ſuch a Train of Moons, before *Caſſini* and *Huygens*? It is reaſonable to think that there are no *Chaſms*, or unneceſſary vacant

cant Spaces in the Solar System. The disproportionately great Distance between the *fourth* and *fifth* of *Saturn*'s Satellites, made the last mentioned great Man suspect, that a *sixth* Satellite revolved in that Space; or (which is more remarkable) that perhaps the uttermost Satellite had other Satellites revolving about it.

*M.* That would be more remarkable indeed, and, I think, past all Comprehension; if a Body revolved about another as its Center, and that other about a third as its Center, and that still about a fourth as its Center, who could conceive this Composition of circular Motions!

*P.* What is hardly to be conceived by us does not therefore become impossible to the Divine Power, if the Conveniency of the Work requires it.

*M.* That is certain.——

*P.* All these sixteen Bodies revolve about the Sun almost in the same Plane; in the same Plane, namely, that which the Earth moves in: But there are *other*, and those *more numerous Bodies*, which traverse the System all Manner of Ways, and which are likewise reckoned to belong to it. Hence you may see how far we are from being certain how many Bodies belong to our own System.

*M.* From what you have said I am satisfied: For why should Bodies be conspicuous

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to us, for whoſe Uſe they were not originally deſigned.

*P.* Conſider alſo that, if they were conſpicuous to us, they would not be adapted to the Uſe for which they were originally deſigned: For (as has been ſaid) it is againſt the Order of Nature, that a *Secondary* ſhould be equal, or nearly equal, to its *Primary*.

*M.* I remember ſtill the *Mill-Stone* revolving about the *Pebble*, and perceive it is mere Unſkilfulneſs to imagine that the Secondaries of other Planets might have been conſpicuous to us. I would gladly know what thoſe *other Bodies* are you mentioned juſt now; but firſt let me aſk,

CIX. Why is it neceſſary that the Satellite of a ſmall Planet ſhould revolve ſo near it?

*P.* I expected to have heard the Reaſon of this from you.

*M.* By this gentle Reprimand I find I have been inattentive to the Conſequences of what has been already ſaid. The Reaſon ſeems to be, that a ſmall Planet muſt have its attractive Force but weak, according to the Quantity of Matter it contains; and the Limit of equal Attraction between it and the Sun at a ſmall Diſtance from it. This will confine its Satellite to a narrow Orbit.

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*P.* Could a Satellite revolve about its Primary at the Extremity of that Limit; or would it in that Case be equally, or nearly equally attracted to the central Body, in all Parts of its Orbit?

*M.* If we could suppose that the Satellite revolved near, or at this utmost Limit; in its opposition to the Sun, it would be attracted with more than all the Force of the central Body, the Sun's Action there conspiring; and in the Conjunction, it would be drawn with no Force at all; the contrary Actions of the Sun and primary Planet there suspending each other. And this must prevent its revolving about a Center in any Manner; as it was in the Supposition we made at our last Meeting, where the *lower Body* was attracted by *that* above it, as strongly the one Way, as the *parallel Forces* impelled it the other. Whence it appears to me that a Satellite, in Order to revolve about its Primary with tolerable Regularity, must be placed a good Way within *this Limit*; that the Inequality of Attraction, in the Opposition and Conjunction, (which must still be something) may have the less sensible Effect.

*P.* What you say is strongly confirmed by considering the Systems of *Saturn* and *Jupiter*. All the Satellites in each of these roll at a vast Distance

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Distance within the Limits of equal Attraction between the Sun and their Primaries. This is observable in their quick Revolutions.

*M.* I remember you said, the innermost of *Jupiter*'s Satellites revolves about him in 42 Hours.

*P.* And a half.

*M.* At what Distance?

*P.* At a Distance from him nearly as great as our Moon is from the Earth; upon the Supposition that the Sun's Distance from us is about 21000 Semi-diameters of the Earth?

*M.* In what Time should it revolve about him at the Limit of equal Attraction?

*P.* It could not revolve at such a Distance, by what you observed just now: But supposing it to revolve at 80 Semi-diameters of the Earth within that Limit, it could not finish a Period about *Jupiter* in less than 700 Days, or near two whole Years.

*M.* There is a great Difference indeed between 42 Hours and a half, and 700 Days. The Light of it at such a Distance must be greatly diminished, I presume.

*P.* It would appear there perhaps but as a faint Glow-Worm in the Sky, hardly affording the 2900th Part of the Light which it shews him at present.

*M.* This

*M.* This is such a Light, I suppose, as a Candle would give at 2 or 300 Paces in a dark Night.

*P.* Here is a Figure, *Matho*, of *Jupiter* and his four Moons, at their proportional Distances from him; and *this Arch* out here at the Extremity of the Paper, shews the Limits of equal Attraction between him and the Sun.

*M.* I see it is a vast Way without the Orbit of his utmost Satellite.

*P.* It is distant from the Center of *Jupiter* about 159 of his Diameters; whereas his utmost Satellite is hardly 13 Diameters from his Center.

*M.* I am not only convinced in Reason, but this shews me in Fact too, that the secondary Planets must revolve a considerable Way within the Limit of equal Attraction between the Sun and their Primaries, in Order to move with no sensible Disturbance. ——But at what Distance might a *Secondary* revolve about *Venus*, or *Mars*, since it is supposed that each of these has a Satellite to attend it?

*P.* It is not so easy to give a positive Answer here, as we know not what Proportion the Quantity of Matter in either of these Planets bears to that in the Sun; for from the

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Quantity of Matter and Diſtance given, it is eaſy to determine the Point between any two Bodies, where their attractive Forces will be equal.

*M.* Yet I ſhould think a probable Conjecture might be made, if we knew the Magnitude of *Venus* or *Mars*, with Reſpect to the Earth; ſince it ſeems the Proportion between the Quantities of Matter in the Earth and Sun can be aſſigned.

*P.* By that Means perhaps we might come pretty near the Truth.

*M.* Is *Venus* leſs or bigger than our Earth?

*P.* Her Diameter is ſomewhat leſs, according to the moſt authentick Obſervations: But as the Bodies nearer the Sun are reckoned more denſe than thoſe farther removed from him, we may ſuppoſe that ſhe contains the ſame Quantity of Matter that the Earth does. And then the Point, where the Sun's Force and hers would ſuſpend each other, muſt fall about 31, 5 Semi-diameters of the Earth from her Center.

*M.* But a Satellite could not revolve about her at that Diſtance.

*P.* Nor a good way nearer, without great Diſturbance from the Inequality of Attractions in the Oppoſition and Conjunction. And though we ſhould ſuppoſe a Satellite to move about

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about her at 22 or 23 Semi-diameter's Distance; it could not appear to us farther removed from her than 12 or 13 Minutes: But in all Probability it is placed much nearer to her. What *Cassini* saw was not above two thirds of *Venus*'s own Diameter distant from her; and very small, though well defined.

*M.* It is no Wonder that such a small Satellite, so near its Primary, should escape Observation.

*M.* As to *Mars*, the Quantities of Matter in the Earth and him, should be as 5, 6 and 1, according to their Diameters, which are nearly as 8 and 4, 5: But as the Earth is a little denser, it may be supposed to contain six Times the Matter in *Mars*. And in this Case, the Limit of equal Attraction between the Sun and him will be 27 Semi-diameters of the Earth from his Center; so that, if we suppose a Satellite to roll about him at 18 Semi-diameters Distance, it could not appear farther distant from his Center than six Minutes. But if it revolved at 3 or 4 Semi-diameters Distance only, which no Body will deny to be possible, and is much more probable, (if we consider the innermost Satellites of *Jupiter* and *Saturn*,) that it might afford him the greater Light, and perform its Revolutions the sooner; it could not

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appear 2 Minutes distant from him. Add to this the proportional Smallness of such a Satellite, and it will be found almost impracticable to discover it. Now if it be but only possible that, though this Planet had a Satellite, it might not be discovered; there is no Reason for concluding, because no Satellite is discovered, that therefore *Mars* has none: And yet this is the only Argument for that Conclusion.

CX. *M.* I perceive the Strength of your Reasoning very well; and what Probability there is that *Mars* should rather have a Satellite than be without one. The Consideration of these Things is extremely pleasant; wherefore let me ask you, What would be the Consequence, or what Difference should we feel, if our Moon were removed to twice the present Distance from us?

*P.* We should not then have four *synodical Months*, (as they are called,) that is, four Conjunctions of the Moon with the Sun, in the whole Year: Nor should we only be without the pleasing Variety of shorter Months, but the Moon then could not afford us above the fourth Part of the Light we enjoy from her at present.

*M.* That

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*M.* That would indeed be a very disadvantageous Change. I have sometimes read a small Print by the Moon-Shine ; but then I imagine the full Moon could not give us more Light than now she does three or four Days after the Conjunction—How would Things be if she were carried off from us to four Times the present Distance ?

*P.* If the Moon were but at twice the present Distance from us, *Matho*, according to your last Question, she could no longer revolve round the Earth as a Satellite ; but below it, as an inferior Planet.

*M.* Well, leaving that Consideration.

*P.* If she were at four times the present Distance from us, we should not have a full Moon once in a Year ; nor could she then give us above the 16th Part of the Light she affords us at present.

*M.* That must be but a melancholy State, when our Months would be as long as our Year, and our Moon twinkled dimly, like a distant Lamp in the Heavens.—But, on the other Hand, what Advantages should we reap if the Moon were but at half the present Distance from us : For, as removing her to a greater Distance, must diminish her Light, and lessen the Frequency of its Returns ; so bringing her nearer us must have the contrary Effects.

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*P.* It is ſo; the Months then would be only about a third Part of our preſent Month, and the Moon would give us four times more Light than now: But as the *Tides* are occaſioned by the Action of the Moon upon the Waters; if ſhe were brought within 30 Semi-diameters of the Earth to its Center, the Tides muſt ſwell to a prodigious Height. All the low Countries near the Sea-Coaſts would be rendered uninhabitable, the Sea for many Miles overflowing them every Time the Moon paſſed our Miridian, either above or below. Our Tides, which now riſe to 9 or 10 Feet, would then ſwell to 68, and in many Places to a greater Height. We can ſcarce figure to ourſelves the Impetuoſity of ſuch a Heap of Waters ſetting in ſucceſſively from the Ocean, on the Coaſts, and falling back with equal Fury.

*M.* I conceive in ſome Sort, what Devaſtation this muſt make: As the Mouths of Rivers are on a Level with the Ocean into which they flow, the Tides would roll far into the Country, and all round muſt be an inhoſpitable Deſert, neither Sea nor dry Land, but a Scene of conſtant Horror, while the Floods ruſhed either the one Way or the other. How much happier then are we as Things now are! May I aſk you after this, What would be the Conſequence to us, if the

the Moon's Distance were but a fourth Part of what it is; or if she were within sixty thousand Miles of our Earth?

*P.* Perhaps the Tops of the Mountains could hardly then afford a safe Retreat to the Inhabitants of the Earth from the tumultuous Sea. I mean it is to be feared, that then the Moon would draw the Ocean almost from its Bed, making it wheel round the whole Face of the Globe, in two opposite Tumors, or Mountains of Water, as the Earth revolved on its Axis the contrary Way. And if this were to be the Case, it nearly coincides with that terrible Disorder we observed before, when we supposed the first Impression of the diurnal Rotation made upon the solid Part of the Globe; but not upon the Waters. Perhaps the Mountains themselves would in Time be dashed to Pieces, or washed down by the Fury of the rolling Floods, and our Planet reduced to a State of Confusion.

*M.* I see the Consequences in both Cases are nearly the same: The not impressing the diurnal Rotation on the Waters there, and the Moon's impressing a contrary Force upon them here, must have had the same Effect.

*P.* It is likewise necessary here to observe, *Matho*, that the Moon, in all Probability, is the largest Satillite in the System, in Compa-

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riſon of her Primary; it can therefore leſs bear her nearer Approach. The Satellites of *Jupiter* and *Saturn* are perhaps larger Bodies than the Earth itſelf; but ſtill they are much leſs in Reſpect of their primary Planets. Therefore their nearer Attraction cannot diſorder the Fluids of thoſe Globes. And upon the ſame Account a Satellite of *Mars*, or of *Venus*, muſt be extremely little, compared with its Primary, in Order to roll about thoſe leſſer Planets at a ſmall Diſtance.

*M.* I was going to aſk you this very Queſtion; namely, What would enſue if the Satellite were equal to its Primary? But you have prevented me. And beſides, thoſe Changes which we think only a Sport of the Fancy to imagine, draw deep, I ſee, in their Conſequences, and affect all Nature round us.

*P.* The Reflexion is extremely pertinent. ——If the Primary and Satellite were both equal in Magnitude and Denſity, the Diſtinction of *Primary* and *Satellite* would be loſt. If their Diſtance were the ſame as at preſent, their periodical Time ought to be ſhortened, to increaſe their centrifugal Force; if their periodical Time were the ſame, their Diſtance ought to be enlarged to weaken their centripetal. If this were the Caſe between the Earth and our Moon, and if the preſent Proportion

portion were once broke; we have no Notion on what Terms it could be healed again. One Thing however is remarkable in this Supposition: That both of them must then necessarily revolve about their common Center of Gravity, (equally distant, in that Case, from either:) Without Room for the Exception I made a little before. Now apply this to the Systems of *Saturn*, or *Jupiter*, where there are five or six Bodies: All these, if equal, ought to be equally distant from their common Center of Gravity, and therefore disposed in the Circumference of a Circle; and at equal Distances from each other in that Circumference. Thus rolling round *that Center*, and keeping still the same relative Situations with Respect to each other, there would be no Difference of periodical Months, nor Foundation for that Proportion between the Squares of the Times and Cubes of the Distances of Bodies moving round a Center; which, if I may so say, is the Key to all our Knowledge of the Motions of the celestial Bodies. Hence taking away the Distinction between *Primary* and *Satellite* would be of bad Consequence in many Respects.

*M.* I find, because we come into a World already prepared and habitable, we are not sensible what Art and Power it required to make

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make it such as we see it: But from these Suppositions, and their Consequences, I perceive how many Ways it was possible for a Power and Knowledge less than infinite, to have miscarried in this complicated, mighty Design. A mere Change of Distance might have made that Moon, which now gently moves the Waters of our Ocean, and chears our Nights, the Ruin of our Globe: And a Change of Magnitude, all Things else remaining the same, must soon have subverted all Nature.

*P.* Nothing could better shew me, *Matho*, that you have a quick Sense of the Subjects we discourse upon, than the natural Observations you often make concerning them.

*M.* I am younger than you, *Philon*, and it is more natural for me to make these Observations, than for the greatest Philosopher.

*P.* What you say surprizes me; pray shew me how that could be.

*M.* You Men have forgot your first Prejudices, and think always on the right Side: These Wonders therefore do not affect you so much. When we come into the World, and first begin to turn our Thoughts on the great Objects round us, we fancy the Constitution and Frame of Nature must be necessary: And when we take the first View

of

of it, as the Effect of Art and Power, and see the Laws observed in the Contrivance, we feel the Opposition between our Prejudices on the one Side, and the Truth of Things on the other, in all its Force.

*P.* This seems not to be without Reason; but it reflects no great Honour on those of riper Years, who either never made these Observations, or have now lost *that Sense* of Things which produces them.

CXI. But are you not already fatigued in pursuing these Matters?

*M.* Not in the least; something new always occurs from what we happen to talk upon: And now methinks I see the Reason why *Jupiter* is placed at such a Distance from *Mars*, and *Saturn* from *Jupiter*; as also, why the next inferior Planet to *these two* ought to have been but small.

*P.* What do you take to be the Reason of all these Things?

*M.* Those two huge Bodies, I suppose, with their Train of Satellites, must by their Attraction have disturbed each other, had not the Space between them been large enough to prevent that Inconvenience: And had the next inferior Planet been equal to either of them, that must have increased the Disorder.

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What you ſaid a little before ſeems to me extremely reaſonable, *That there can be no Chaſms, nor unneceſſary vacant Spaces in the Syſtem.*

*P.* Your Conjecture is confirmed by the Obſervation of Aſtronomers; for while thoſe two uppermoſt Planets paſs each other, notwithſtanding their great Diſtance, they are obſerved ſomewhat to affect each other's Satellites. And had the Planet next to them, (or indeed any of the inferior Planets) been equal to either of theſe, not only the upper Parts of the Syſtem, but the Center itſelf, would have been ſenſible of the Difference. When the Planets happened all to be on one Side of the Sun, and no Balance on the other, *Saturn* muſt have been more diſturbed in his Courſe, and the central Body itſelf ſhaken.

*M.* Then it ſeems, placing the little Planet *Mars* in the Gap between our Earth and *Jupiter*, as alſo the whole Diſpoſition of the Planets, was not merely arbitrary, and indifferent, as is generally thought, but the Reſult of pre-contrived Order and Convenience.

*P.* You will perhaps ſee more of this as you go on. When we have weighed Things maturely, and conſidered the Forces of the Sun and Planets, according to the known Laws of Gravitation; we ſhall find that this large

large Interval, which we may think employed to little Purpose, is in the main the greatest Frugality of Space.

*M.* You said just now that, were either of two attracting Bodies made larger, the periodical Time ought to be shortened to increase the centrifugal Force; or the Distance between the two Bodies ought to be widened to weaken the centripetal: Now, though you have already told me something concerning the Law of the centripetal or attracting Force; yet pray resume the whole Matter, and lead me into it in a familiar way, if possible.

*P.* Good, *Matho*, you are like to cut out more Work for us than, I'm afraid, either of us will be able to go through.

*M.* Enough of your Art, *Philon*, you have already, by your pretended Difficulty, screwed my Curiosity to the greatest Height.

*P.* I would do every Thing to oblige you, except spoiling a noble Subject, and making it more intricate, through my Want of Ability to communicate it to you easily: But since it must be so, let me first observe to you, that I shall be better able to explain these Particulars by bringing Examples, than by shewing you the Reasons of them from Nature.

*M.* Without apologizing for yourself, that is the fittest Method to be taken with me.

*P.* The

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*P.* The centripetal Force, you remember, is the immediate Work of the Deity; and though he might have appointed other various Laws according to which Bodies might have gravitated to each other, yet this is the Law which for wiſe Reaſons he has made to obtain, *That the Gravitation between two Bodies ſhould always be inverſely as the Squares of their Diſtances from each other.*

*M.* This I remember; but let me apply it to the ſeveral Suppoſitions we made before concerning our Moon, that the Thing may become more obvious——If the Moon had been at half the preſent Diſtance from the Earth, ſhe muſt have been attracted four Times as ſtrongly by it, as now?

*P.* Certainly.

*M.* And then you ſay her periodical Time muſt have been but about a third Part of our preſent Month, in Order to increaſe her centrifugal Force, and prevent her being drawn down to the Earth?

*P.* It is ſo; our Month then would have been to our Month now, as 1 to 2, 828.

*M.* And her Celerity then muſt have been greater?

*P.* Without Doubt; as ſhe performed near three Revolutions for one, and but at half the Diſtance.

*M.* Again,

*M.* Again, had the Motion been but at a fourth Part the present Distance from us; we must have been attracted sixteen Times as strongly as now?

*P.* You are right.

*M.* And our Month then must still have been shorter?

*P.* It must have been just an eighth Part of our present Month.

*M.* And therefore her Velocity must have been greater, to give her more centrifugal Force?

*P.* Unquestionably; for having sixteen Times more centripetal Force, her centrifugal Force ought to be increased equally, to prevent her being brought nearer the Earth.

*M.* On the other Hand, had the Moon been at twice the present Distance from the Earth, it must have attracted her but with a fourth Part of the Force it does now; and we could not have then had four synodical Months (as you called them) in the whole Year; or her Celerity must have been less, to weaken her centrifugal Force, and bring it also to be a fourth Part of the former.

*P.* In all this you are extremely right.

*M.* And had she been four Times farther removed from us, she must have been attracted but with a sixteenth Part of the present Force;

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Force; in which Caſe we could not have had a full Moon once in a Year; and her Celerity muſt have been ſo diminiſhed, as to leave her but a ſixteenth Part likewiſe of her former centrifugal Force.

*P.* You remember the Caſe very well, and conclude very rightly.

*M.* From hence then it follows that, as Change of Diſtance from the attracting Body changes the centripetal Force; ſo changing the Velocity of the revolving Body changes the centrifugal.

*P.* It muſt of Neceſſity.

*M.* But as the centripetal Force is increaſed or diminiſhed, inverſely as the Squares of the Diſtances; is not the centrifugal Force alſo increaſed or diminiſhed in a certain regular manner?

*P.* It is.

*M.* Now indeed I call to Mind the Inſtance of the Stone whirled round in a Sling, when you told me that the centrifugal Force was changed in a very regular manner.

*P.* You call to Mind that Particular very opportunely.

*M.* Pray then ſhew me after what Proportion it becomes greater or leſs; for I perceive, if we knew that, we might underſtand how it is that the two Forces balance each other;

other; so that a Planet is neither drawn down to the central Body, nor flies out from it. Eighth Conference.

CXII. *P.* Here you must know that, though the Law of the centripetal Force be arbitrary, and might have been different from what it is, had it so pleased the Creator; the centrifugal Force, on the contrary, rises from a Necessity of Nature; or, to express it more justly, from the Resistance of Matter, by which a Body always tends to move on in a straight Line.

*M.* We talk'd of this long ago, when we first considered the circular Motions of the Planets.

*P.* Hence therefore a Body must resist being put out of its Direction (that is, it must exert a centrifugal Force) not only according to the Celerity with which it is carried round; but also by so much the oftner as it is drawn out of its Direction by the centripetal Force in the same Time, or hindered from going on in a straight Line.

*M.* This seems plain; it must resist each Time it is pulled in, as it were, towards the Center; and if a Body is, by a repeated attractive Impulse, four or five Times drawn inward from its projectile Direction, in the same Time that another is but once diverted

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from that Direction, their Celerities being the ſame, it muſt have four or five Times the centrifugal Force of the other. However as the centrifugal Force here depends on *two different Cauſes*, pray ſpeak of them ſeparately, that I may the more clearly conceive what Share each has in producing the Effect.

*P.* With all my Heart. Let us therefore ſuppoſe that another Moon, at a four Times greater Diſtance than ours, were carried round the Earth in the ſame Time; and then tell me what Celerity ſhe muſt have, with reſpect to the interior Moon?

*M.* Four Times a greater Celerity; becauſe ſhe moves round a four Times larger Circle in the ſame Time.

*P.* The Periphery of it is certainly four Times longer.

*M.* That is what I meant; for the circular Space itſelf is ſixteen Times larger.

*P.* Therefore as ſhe moves with four Times a greater Celerity, ſhe muſt have four Times a greater centrifugal Force; for ſhe has four Times a ſtronger Tendency to go on in a ſtraight Line.

*M.* This I think I conceive: And if her Orbit were only twice as wide, ſhe would have but twice the centrifugal Force of the inner Moon, becauſe but twice her Celerity.

For

For I suppose there are as many Deviations from moving on in a straight Line, in the Circumference of a less Circle, as in that of a greater.

*P.* Certainly; because the least returns back upon itself, as well as the greatest. And if you conceive a Compass so contrived, as to describe two concentrical Circles at once; like Parts of both Circles require an equal turning round of the Compass; and therefore equally deviate from straight Lines.

*M.* So far I understand then; when two Bodies revolve about a Center in the same Time, and there is no Difference except in the Celerity, or Wideness of their Orbits, their centrifugal Forces will be as their Celerities. This likewise is the Case when we suppose the Earth to revolve about the Sun at a greater, or less Distance, still in the same Time: The centrifugal Force, and therefore the centripetal, is always as the Earth's Celerity in its Orbit, or as its Distance from the Sun.

*P.* The Application is very just.——But to come to the *second Cause* of the Increase of centrifugal Force; suppose now that more Revolutions of the inner Moon were performed in the same Time: And the Reckoning will become different.

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*M.* Give me an Example.

*P.* If the inner Moon, inſtead of one Revolution, performed two in the ſame Time; what Celerity muſt ſhe have?

*M.* Twice her former Celerity; that is, half the Celerity of the exterior Moon.

*P.* And how often would ſhe be retracted from going on in a ſtraight Line, in theſe two Revolutions?

*M.* Twice as often certainly, as in one Revolution.

*P.* Join the Effects of theſe two different Cauſes together, and then tell me what her centrifugal Force will be?

*M.* Give me Time to conſider this.——In her two Periods ſhe is twice as often retracted from going on in a ſtraight Line, as in one; or twice as often reſiſts being turned out of that Direction; and at each Time with double the Force, becauſe with double the Celerity:—Therefore her centrifugal Force is twice double, or quadruple of what it was.

*P.* It is juſtly enough reaſoned, *Matho*; but could you not make it a little plainer?

*M.* I underſtand the Thing, but have not a Command of Words.—Twice the Number of Retractions in the ſame Time will make the Body reſiſt twice as much being put out of its Direction, or exert a double centrifugal Force

Force in the same Time; and double the Celerity will make it double of this Double. Eighth Conference.

*P.* This will indeed shew that in the whole Time of the two Revolutions, the Body exerts a quadruple centrifugal Force, of what it does when it performs but one Revolution in that Time: But how will it shew that the Body exerts a quadruple centrifugal Force in any Instant of that Time?

*M.* Since the Body moves equally in its Orbit, or does not exert more Force in one Part than another; divide the Time into any Number of Instants you please, and the whole Sum of the centrifugal Force into as many Parts; and still the centrifugal Force in any Instant, when the Body performs two Revolutions, will be quadruple the centrifugal Force in the like Instant when it performs but one.

*P.* I perceive now you understand the Matter thoroughly; nor is the Argument different on any other Supposition: If the inner Moon is carried three Times round instead of once, she must move with thrice the Velocity, and exert her Tendency of going on in a strait Line thrice as often; that is, she must exert thrice the triple of her first centrifugal Force in the same Time: Or her centrifugal Force is now nine Times greater than it was.

*M.* Or if she performed four Revolutions for one, she must exert four Times as often

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her centrifugal Tendency, with four Times the Celerity; or have four Times the Quadruple of her first centrifugal Force. So that the centrifugal Force here increases with the Squares of the Number of Revolutions performed in the same Time.

*P.* That indeed is the Law, resulting, you see, from the Inertia, or Inactivity of Matter.

*M.* But a Body revolving about another, must either be drawn nearer to it, or carried farther from it, unless these two Forces, the centrifugal and centripetal, balance each other.

*P.* It must.

*M.* What Method can there be then of bringing them to an Equilibrium; since the one Force is *arbitrary*, and the other the *necessary Effect* of the Inertia of Matter?

*P.* A Method of accomplishing his Designs can never be wanting to the Deity: It is from bringing these Forces to an Equilibrium, *Matho*, according to the different Distances of the Planets from the central Bodies, that the beautiful Proportion flows, which we have so often spoke of, between the Cubes of the Distances, and Squares of the periodic Times.

CXIII. *M.* Since therefore we have fallen so naturally into this Subject, pray take the Trouble to shew me how this Proportion results from bringing these contrary Forces to an Equality:

Equality: For the Explication seems to follow easily from what we have already said.

*P.* It does indeed; nor should I think it a Trouble: But seriously I am afraid that so many new Things will be apt to confound each other in your Memory.

*M.* Their Connexions and Dependance rather will bring them back in Order. Only go on in the same plain Method, and by the Help of Examples: This makes the abstract Reasoning more palpable, and hence the Things will stick better with me.

*P.* Well, since you will have it so, let us keep still to our two Moons, the one at four Times a greater Distance from the Earth than the other; and if both revolved about it in the same Time, in what Proportion should their centrifugal Forces be?

*M.* The centrifugal Force of the more remote, as we said just now, must be four Times greater than that of the *nearer*; as having four Times the Celerity, and but once the Number of Deviations from the projectile Direction.

*P.* And in what Proportion should their centripetal Forces be?

*M.* Stay a little till I recollect.——The centripetal Force becomes greater, as the Square of the Distance becomes less.——It

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is ſo. The centripetal Force of the inner Moon, *Philon*, ſhould be ſixteen Times greater than that of the *other*.

*P.* If then we ſuppoſe that theſe Forces are equal in the exterior Moon, what Difference will there be between them in the *nearer*?

*M.* Stay a little—The inner Moon hath ſixteen Times a greater centripetal Force, and only the fourth Part of the centrifugal. Bleſs me! How ſoon muſt ſhe be drawn down to the Earth!——She has only the ſixty-fourth Part of the centrifugal Force which ſhe ought to have, that it may balance the centripetal, and keep her moving in a Circle about the Earth.

*P.* Explain this Point a little more diſtinctly, if you can.

*M.* Theſe two Forces are equal in the exterior Moon: But the centripetal Force of the *nearer* is ſixteen Times greater than the *one* of them, and the centrifugal Force only a fourth Part of the *other*. Wherefore it is plain that this laſt Force muſt be ſixty-four Times greater than it is, (that is, ſixteen Times greater alſo than the centrifugal Force of the exterior Moon) that it may balance its contrary centripetal Force.

*P.* You have now made it plain enough: But how is her centrifugal Force to be increaſed,

creased, that it may become sixty-four Times greater than it is? Eighth Conference.

*M.* Give me a little Time to think of it: This is pretty crabbed Work for a Beginner. ——The centrifugal Force is increased with the Square of the Number of Revolutions performed in the same Time.—That Square ought to be sixty-four—Therefore the Number of Revolutions ought to be eight—I'm sure this is right enough.—Now, *Philon*, if the inner Moon performs eight Revolutions, while the outer Moon performs one, she must have her centrifugal Force equal to her centripetal, and neither be drawn down to the Earth, nor carried off from it, but return always in the same Track.

*P.* Notably done, *Matho!* You have behaved like a Hero!

*M.* I am glad of it; but here a Difficulty seems to occur.

*P.* What is it?

*M.* If one Revolution of this exterior Moon were only equal to eight Revolutions of ours, she must certainly be in Conjunction with the Sun in less Time than a Year: And you seemed to say the contrary when I asked you, What Difference there would be, if the Moon were at four Times the present Distance from the Earth?

*P.* There

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*P.* There is no Difficulty in this Case, *Matho:* For though the *periodical Month* of a Moon at four Times the Distance of ours should consist of about 218 Days; yet 327 Days more ought to pass, before she could again overtake the Sun, or get between the Earth and him. Because the Earth in the Interim must have moved a great Way forward in its annual Course round the Sun: And it would not be enough for the Moon to come opposite to the Point where the last Conjunction happened; she must still move forward, 'till she get between the Earth and Sun again. Here her *synodical Month* therefore should be more than twice as long as her *periodical*; and consisting of about 545 Days, two Lunations would hardly happen in three Years.

*M.* I have some Notion of this: The *periodical* and *synodical* Month would always be equal, if the Earth stood still: But as the Earth moves, the Moon has so much more to run over, after her periodical Month is finished.

*P.* It is so; and at present the *synodical Month* is about two Days longer than the *periodical.*

*M.* Well, to return:

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CXIV. Let me consider what I have done, or how the Proportion between the Squares of the periodic Times and Cubes of the Distances appears from this Number of Revolutions.

*P.* You see the Distance of the interior Moon is 1, and of the *exterior* 4.

*M.* Right.

*P.* The Cubes of these are 1, and 64.

*M.* They are.

*P.* The periodic Time of the interior Moon is 1, and of the *exterior* 8.

*M.* Certainly; since the one is eight Times the other.

*P.* But the Squares of these are likewise 1 and 64.

*M.* O *Philon!* You have made me happy! For it was the Height of all my Wishes, (if I may say so,) to understand this; and now I do understand it. This is not only an Example of the Proportion; but it shews from the Nature of Things, how these Motions must be in this Proportion.

*P.* This is the Law, *Matho*, which obtains in the Motions of all the Primary Planets round the Sun; and also in the Motions of all the *Secondaries* round *the same Primary*.

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*M.* I remember you told me that they who placed the Earth in the Center of the Syſtem, and ſuppoſed the Sun to revolve about it, in the fourth Place, (namely, above the Moon, *Mercury* and *Venus*) confounded this beautiful Law of the planetary Motions.

*P.* They do Violence to Nature itſelf; ſince the centrifugal Force, or the Reſiſtance of Matter on which it depends, is ſtubborn and unyielding: For, let us ſuppoſe that the Diſtance of the Sun from us was but 12000 Semi-diameters of the Earth, or 200 Times the Diſtance of the Moon; and then the Cubes of their Diſtances will be 8000000 and 1: The Square-Roots of which Numbers are 2828 and 1. So that the periodical Time of the Sun ought to be 2828 Times that of the Moon: That is, either our preſent Year ought to contain 2828 Revolutions of the Moon, each conſiſting of about three Hours, ſix Minutes; or our preſent periodical Month ought to be but the 2828th Part of the Year; whence one Revolution of the Sun would be equal to 211 of our preſent Years. Either of which is monſtrous.

*M.* Thoſe Philoſophers are as far wrong in this Reſpect, it ſeems, as in ſuppoſing that ſuch a ſmall Body as the Earth could reſiſt the attractive Force of the Sun and Planets, without being drawn from its Place.

*P.* They

*P.* They might easily be excused, *Matho*, in not discovering this Law of the celestial Motions; but not to own the Mistake they were under, after it was discovered, is something worse than Ignorance.

*M.* Pray give me another Example of this Proportion, that I may apply the same Reasoning to Bodies revolving at other Distances.

*P.* Suppose two Planets revolving about the Sun, the one 5 Times more remote from him than the other, which is nearly the Case between *Jupiter* and our Earth; and then—

*M.* Permit me to go on with the Argument myself.—The Earth, being but at a fifth Part the Distance, will have 25 Times more centripetal Force than *Jupiter*; and, if they had performed their Revolutions in the same Time, it must have had but a fifth Part his centrifugal Force. Therefore, if we suppose these two Forces to balance each other in *Jupiter*; when the Earth has got five Times more centrifugal Force than it hath, it will still have but the centrifugal Force in *Jupiter*, or the 25th Part of what it should have, that its centrifugal Force, as well as centripetal, may be 25 Times that in *Jupiter*, and consequently the one balance the other.

*P.* You

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*P.* You expreſs the Matter very clearly: Go on.

*M.* Since the Earth muſt have 125 Times more centrifugal Force than it has, that Number 125 muſt be the Square of the Number of Revolutions which it performs in the ſame Time that *Jupiter* performs one; or it muſt perform ſome more than eleven Revolutions for *Jupiter*'s one; for 121 is the Square of 11.

*P.* The Square-Root of 125 is 11, and about two tenths.

*M.* Then the Diſtances being 1 and 5, the Cubes of theſe are 1 and 125; and the Times being 1 and 11,2; the Squares of theſe are likewiſe 1 and 125.

*P.* All this is perfectly right, *Matho*; and on this Suppoſition you ſee *Jupiter*'s periodic Time muſt be ſome more than eleven Years: But had we taken the Proportion of the two Diſtances more exactly, which is ſomewhat greater than that of 5 to 1, *Jupiter*'s periodical Time would have been 11 Years and about 314 Days, which it really is. However it was needleſs to have affected ſuch Nicety, which muſt have engaged you in a more tedious Computation; ſince the Reaſon of the Thing appears as well from one Diſtance as another.

*M.* As

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*M.* As this Proportion holds in the Motions of all the Planets revolving about the Sun, I shall try the Computation by myself; since I have their Distances and periodical Times in the first Diagram you gave me.

*P.* By that Means you may make this fundamental Theorem familiar to yourself.

*M.* As to its being *fundamental* I am not yet so good a Judge: But certainly it is an amazing Instance of the Power and Wisdom of the Creator, to impress these different Forces on the same Bodies in such a Manner, that while the *centripetal* always impells the Planets inversely as the Squares of their Distances from the central Body; the *centrifugal* is proportioned to it in that only Quantity, by which a circular Orbit could be described!

*P.* Let those Persons, *Matho*, look to these Motions of the Sun, Moon, and Planets, who suppose that the *Deity* must be an indolent and slothful Being; or perhaps only a mere Name, and State-Trick of the first Legislators, to fright Men into a Compliance with their Schemes.

*M.* O strange! *Indolent,* or a *mere Name!* What Proof of *almighty Power* would they have; or could they comprehend? Are not these Motions exposed to the Eyes of all? Or would it satisfy them that there were an *all-*

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*powerful Being*, who preſerved the World, if the heavenly Motions were ſtopt, and Nature went into Confuſion?

*P.* You have Reaſon to aſk this contradictory Queſtion: For when Men refuſe their Aſſent to the moſt plain and natural Proofs, it looks as if they would be ſatisfied with their Contraries; that is, with no Proof at all; or rather that they are reſolved not to be ſatisfied.

CXV. *M.* Since it is certain from *Obſervation*, that the Squares of the Times of the Planets round the Sun are as the Cubes of their Diſtances from him; and ſince you have ſhewn me according to what Law the centrifugal Force is increaſed or diminiſhed; I now ſee plainly, and any Body may from thence gather, that their Attraction toward the Sun is inverſely as the Squares of their Diſtances from him.

*P.* Shew me how you collect this?

*M.* The centrifugal and centripetal Force of any Body deſcribing a circular Orbit about another, muſt be equal: But by examining the centrifugal Forces of any two Bodies, according to the Rules you have explained to me, I find theſe are inverſely as the Squares of the Diſtances of the two Bodies from the

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central Body. Therefore I conclude, their centripetal Forces, which are equal to these, must be in the same Proportion.

*P.* Your Argument is good; but apply it to some of our former Examples.

*M.* In the Example of our two Moons, one at a four Times greater Distance from the Earth than the other, the nearer Moon hath double Celerity, and deviates eight Times oftener from the projectile Direction in the same Time, than the *exterior*: Hence she must have sixteen Times more centrifugal Force, and therefore sixteen Times more *centripetal*, than the Moon at four Times the Distance. And from this I now see that the Proportion between the Squares of the Times and Cubes of their Distances is indeed a *fundamental Article* in order to understand the Law of the Planetary Motions.

*P.* It is as you say; from that once discovered the rest becomes easy.

*M.* I am likewise satisfied from this Argument, *viz.* Since the Squares of the periodical Times of Satellites revolving about the same *Primary*, are as the Cubes of their Distances from it; that they cannot be more, nor so much attracted to any other Center, as to that of the Planet about which they move. For if they were but equally attracted to

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another Point, their Attraction to that Center would be nothing at all, instead of being inversely as the Squares of their Distances: Whence that Proportion must be spoiled.

*P.* You are right: Since *no Attraction at all* could have given Foundation *to no Proportion at all.*——

*M.* But you said that other Laws of Attraction might have been appointed by the *Creator*, had he so pleased.

*P.* Surely; for the Attraction might have been directly as the Distances, or inversely as the Distances; or directly as the Square-Roots of the Distances, or inversely as the Square-Roots of the Distances; with an endless Number of other Suppositions, which were all equally possible to the Deity, though not equally convenient for the Nature of his Work.

*M.* Pray give me an Example of this, that I may see the Difference between any of these, and our present Constitution?

*P.* You need only to be put in the Way, to pursue any of these Cases by yourself. Tell me then, if the Attraction had been directly as the Distances, and one Planet had been removed to twice the Distance of another from the Sun, in what Proportion would their centripetal Forces have been?

*M. That*

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*M. That* at twice the Distance must have been twice as strongly attracted; according to its double Distance, to wit.

*P.* And their centrifugal Forces?

*M.* These must have been in the same Proportion, to balance their contrary centripetal Forces; if they were both to move in circular Orbits.

*P.* By what Means could the Planet at double the Distance have had double the centrifugal Force, to balance its double centripetal Force?

*M.* If it had performed a Revolution in the same Time, its double Celerity must have given it a double centrifugal Force. For on this Supposition the centrifugal, as well as centripetal Forces must have been as the Distances. And—at this Rate—all the Planets must have revolved about the Sun in the same Time: For then their centrifugal Forces must all have been as their Celerities, or Distances from the Sun.

*P.* It is so; the outermost *Saturn* must have performed a Revolution, as soon as the innermost *Mercury*.

*M.* Let me go on; I think I see still something farther. In that Case they could never have changed their relative Situation with Respect to each other; *Saturn* or *Jupiter*

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performing half, or any Part of a Revolution, as ſoon as *Venus* or *Mercury*. And if at the Beginning of their Motions, ſome Bodies had been placed on the oppoſite Side of the Sun, with Reſpect to others, they could never have had Sight of each other, but always remained in that Oppoſition, obſcured by the Sun's Rays. Or had an interior Planet been placed directly between another and the Sun, it muſt ſtill have appeared as a Spot upon his Diſk. In ſhort, our preſent Conſtitution ſeems every Way preferable to this.

*P.* It is likewiſe more natural, *Matho*, that the Attraction ſhould go on decreaſing from the Sun, as well as the Heat and Light, and decreaſing in the ſame Proportion; rather than increaſing.— Again, If the Gravitation to the Sun had been inverſely as the Diſtances, what muſt have been the Conſequence?

*M.* A Body at half the Diſtance muſt have been doubly attracted, and ought therefore to have had double the centrifugal Force of another at the whole Diſtance.

*P.* And if they had performed their Revolutions in the ſame Time?

*M.* The innermoſt could have had but half the centrifugal Force of the other; or one fourth of what it ſhould have had.

*P.* How

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*P.* How could it have got four Times as much centrifugal Force?

*M.* If it had performed two Revolutions for one. And from this I see the rest: For since the interior Orbit was half the exterior, and the interior Planet revolved twice in the Time the *exterior* revolved once, their Celerities must have been equal, and therefore their periodical Times directly as their Distances from the Sun.

*P.* You are perfectly right. If this had been the Law of Gravitation in our System, the Celerities of all the Planets must have been equal, and their periodical Times as their Distances. *Jupiter* must have performed a Revolution in some more than five Years, and *Saturn* in something less than ten.

*M.* I am delighted with this Sort of Reasoning, and fancy, without giving you more Trouble, I shall be able on any other Supposition to draw the Consequences for myself, and find out on what Terms the centripetal and centrifugal Forces are to be brought to an Equilibrium, so that the Body should describe a circular Orbit.

*P.* It will not be difficult.

CXVI. *M.* I now begin to understand what I desired to be informed of in the be-

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ginning of our Diſcourſe; namely, That all theſe ſixteen Bodies could not have revolved about the Sun immediately, as the Center of their Motion, without great Inconvenience.

*P.* In what Reſpect?

*M.* The more remote Planets muſt then have been deprived of their Moons, which, by reverberating the Sun's Rays upon them, diverſify and chear their Nights.

*P.* They would likewiſe have ſuffered another Loſs, *Matho*, not inferior to this, in that the exterior Planets muſt have been removed to a much greater Diſtance from the Sun.

*M.* I have a Notion why this muſt have been; but pray aſſiſt me.

*P.* Our Moon, for Inſtance, by revolving about the Earth, as a Center, muſt neceſſarily be brought near it, that ſhe may be within the Bounds of its ſtronger Attraction: But had ſhe revolved directly about the Sun, ſhe muſt as neceſſarily have been removed to a great Diſtance from the Earth, that ſhe might have been on the other Side of that Limit; leſt the prevalent Attraction of the Earth ſhould have diſturbed her Motion, or drawn her the contrary Way.

*M.* This is indeed very obvious from what has been ſaid before: She muſt have then rolled a conſiderable Way without that Limit, as now ſhe moves within it. *P.* If

*P.* If then we consider *Jupiter* and *Saturn*, those larger Planets, attended each with a System of Satellites; their Moons, in this Case revolving separately about the Sun, must have been removed to a vast Distance from them. Eighth Conference.

*M.* To a vast Distance certainly, if (which seems reasonable) they ought to have been placed as far without the strong Force of these huge Bodies, as now they are within it. For in those remote Regions, where the Sun's attractive Power becomes comparatively weak, the Force of *Jupiter* and *Saturn* reigns far and wide.

*P.* We may in some Measure guess to what a Distance their Satellites ought to have been removed from such huge Bodies, in that Case, when we consider that they disturb each other's Satellites at an immense Interval in the present Dispositon.

*M.* That I did not think of: I find now you had good Reason to say, *That the large Interval, which we may think laid out to little Purpose, is notwithstanding, when maturely considered, the greatest Frugality of Space.* Any of the Satellites of these great Bodies must then have been as far removed from either of them, as now the Bodies themselves are distant from each other.

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*P.* If therefore all the Planets, as well Secondary as Primary, had revolved about the Sun ſeparately, as the immediate Center of their Motion, *Saturn*, you ſee, muſt have been removed much farther from the Center than at preſent, and the Bounds of the whole Syſtem greatly enlarged.

*M.* To near double, I preſume; and the periodical Times of the Planets muſt in Conſequence have alſo been lengthened, according to the Proportion we have ſpoke of.

*P.* Without doubt: Had *Saturn* been at double the Diſtance, he could not have completed his Revolution in leſs than eighty-two Years.

*M.* Hence I ſee then, if all theſe ſixteen Bodies had revolved ſeparately about the ſame common Center, as now the Primary Planets do, they muſt have ſuffered two Loſſes equally great; having the Heat and Light of the Sun more faint and languid by Day, and no vicarious Luminary to ſupply his Place by Night.

*P.* All that Variety of Light, *Matho*, we ſo much admired before, all thoſe Viciſſitudes, and glorious Phænomena in the Heavens, are quite extinguiſhed on this Suppoſition.

*M.* In Truth I think it is hardly poſſible to conſider the preſent Diſpoſition of the Syſtem,

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Syſtem, and how uſeful the ſeveral Bodies in it are to each other, without being full of a Senſe of Love and Gratitude to the Creator, for his indulgent Care and Proviſion. Were we deprived but of our Moon, it would not be eaſy, I believe, to find out all at once the ſeveral Loſſes we ſhould ſuffer.

*P.* It is reaſonable to think, we could only diſcover ſome of them by feeling them.

CXVII. *M.* What we have ſaid juſt now ſuggeſts a Reaſon, I think, Why the outermoſt Planets ought to have been larger than thoſe nearer the Sun.

*P.* For what Reaſon then doth it appear to you that this was ſo ordered?

*M.* By how much the exterior Planets were to be more diſtant from the Sun, ſo much the more were they to ſtand in need of the Relief and Comfort of thoſe Satellites, or vicarious Luminaries: And had they not been prodigiouſly large Bodies, in reſpect of the interior Planets, their attractive Force could not have been ſtrong enough to keep each of them a Syſtem of Moons rolling about itſelf.

*P.* I am entirely of your Opinion. *Saturn* we ſee, in the utmoſt Regions of the Syſtem, is able to retain five or ſix ſecondary

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Lights rolling round him; and *Jupiter*, though near about the middle of it, keeps four: Whereas had any of the four lower Planets been ſet off to the utmoſt Parts of the Syſtem, they could hardly have retained one Satellite, againſt the Attraction of *all the great Bodies* lying near the Center. We may imagine that great Bodies placed near the Center might have been more proper and uſeful; but we do not conſider the Inconvenience of ſuch a Diſpoſition. The Syſtem in that Caſe could not have conſiſted of near ſo many Bodies, nor thoſe near ſo uſeful to one another.

*M.* Beſides the Inconvenience, the preſent Order ſeems more agreeable and decent. It would have had the Appearance, in ſome ſort, of Neglect and Careleſſneſs, had the leſſer Planets been thrown to the out-ſide: But theſe larger Bodies incloſing the Syſtem look ſtately and magnificent.

*P.* Add to this likewiſe, *Matho*, (ſince the Celerities of the Planets are reciprocally in the ſub-duplicate Ratio of their Diſtances from the Sun;) that it muſt have appeared againſt the Order of Nature for ſuch a mighty Body as *Jupiter* to have been carried round with the rapid Motion of *Mercury*; or that *Mercury*, *Venus*, or our Earth.

should have moved at the slow Rate of *Saturn* or *Jupiter*.

*M.* It does not indeed seem natural for a Body to move the faster, the larger it is: But explain a little, if you please, this Proportion of the Celerities of the Planets.

*P.* I dare say, if you consider it, you will be able to make this out by yourself.

*M.* The Truth is, I do not understand what you mean, by being *reciprocally in the sub-duplicate Ratio of the Distances*.

*P.* That is only, that the Celerities of the Planets are inversely as the Square-Roots of their Distances from the Sun.

*M.* This is more intelligible, and now I fancy I can deal with it, by the help of our former Example of the two Moons.—— The *interior* had her Orbit but a fourth Part of that of the *exterior*, and she performed 8 Revolutions for the other's one; so that her Celerity was double that of the other: Or their Celerities were as 2 and 1. But 2, the Velocity of the *nearer*, is the Square-Root of 4, the Distance of the *more remote*, that is, their Velocities were inversely as the Square-Roots of their Distances.

*P.* I find I was in the wrong, *Matho*, to affect such a learned way of Speaking; Good Sense has not fair Play, when it is oppressed with

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with hard Words: But I ſhall be on my Guard for the future.

*M.* If then the Diſtances of the Earth and *Jupiter* from the Sun were as 1 and 5, their Celerities would be contrarily as the Square-Roots of 5 and 1.

*P.* You are perfectly right; and it is ſo in all other Caſes.——

*M.* Leaving this, pray let me obſerve to you, leſt I forget it, one ſingular Advantage with reſpect to the ſhortening the Darkneſs of our Nights here on this Planet, which I have often thought of by myſelf.

*P.* What is it?

*M.* I underſtand from what we ſaid formerly, concerning the annual and diurnal Motions of the Earth, that we are exactly half the Time in the Rays of the Sun, and the other half in the Shade of the Earth: And yet a great deal more than the half of our Time is Day-Light, if I may ſo expreſs it; for if we take in our *Morning-Dawn*, and *Evening-Twilight*, they ſhorten the dark Half of our Time, by at leaſt three Hours every Night.

*P.* This, among many others, is an Advantage we reap, *Matho*, from the Conſtitution of our *Atmoſphere*, which ſpread round the whole Earth, does the Office of a Moon for

for some Hours every Night, by reflecting the Light of the Sun in upon the Globe it surrounds. Were it not for this Contrivance, intense Darkness would succeed to the Sun-Light, not gradually as now, but in an Instant: And contrarily, the Light of the Sun to intense Darkness. The Traveller would be benighted in a Moment after losing Sight of the Sun: Nor in the Morning should we be able to bear the sudden Change from thick Shades to bright Sun-shine. It would be like bringing a Man from Confinement in a dark Dungeon, all of a sudden into open Day.

*M.* O the Goodness of the *Creator!* As Light is a precious Thing, how many wonderful Ways has he taken to supply it to his Creatures! Who of a thousand thinks now on this Advantage? It seems to be one of those Cases, where we could only discover our Loss by feeling it.

*P.* We are graciously prevented with the Comforts of Life; and therefore, as you observed a little before, we imagine Things could not have been otherwise than they are.

*M.* I remember you told me before that our Atmosphere is *a Scene of Wonders*; and I think this is one, *That the Air should be so transparent and pure, as to transmit to us the Light of the fixt Stars; and yet so gross* (if I may

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I may uſe that Word) *as to reflect on us the Light of the Sun when abſent.*

*P.* The Air that ſurrounds our Globe, *Matho*, is as neceſſary to our Support, as the Globe itſelf. This elaſtick Fluid is to us the Breath of Life: It is in all the Parts of our Bodies, and by a Counter-Preſſure which we feel not, preſerves them conſtantly from being cruſh'd: It is many Ways abſolutely neceſſary to Vegetation; the Vehicle by which Dews and refreſhing Showers are conveyed to the otherwiſe barren and thirſty Mold; and with all this it is the very Spirit of Fire and Flame, without the Uſe of which Life would be miſerable.

*M.* I ſee on every Hand by what Inſtances of Power and Kindneſs the Creator hath guarded his Works againſt the Exceptions of ignorant Mortals: All this is performed by Means of an Element, which we think ſcarce deſerves our Attention.

*P.* It is true; but in the Nature of Things there is no guarding the Works of Knowledge againſt the Calumnies of Ignorance, ſince the more artful the Performance is, the more ſuch People carp at what they do not underſtand. Let us leave them then to the Reproaches of their own Mind, to which

which a small Acquaintance with the Works of Nature will expose them.—

*M.* I was going to ask you about the Elasticity of the Air, and why you think it is in every Part of our Bodies; but I am afraid of troubling you.

*P.* A few plain Experiments will make you know more of the Elasticity of the Air, than I can tell you. The Weight of the Atmosphere is balanced by this Repellency between its least Parts. The Pressure of it therefore upon all the Parts of our Bodies, is counter-poised by this Repellency of the Particles in all Parts of the Body; and not at all by our soft Flesh, and less by the Repellency of the outward Particles, one against another; because the Surfaces or Figures of our Bodies are not fitted to that Purpose. When the Pressure is taken off one Part of the Hand, by laying it on the Mouth of a Glass out of which the Air is drawn, we feel a great Force and Pain. This is because the internal Particles have nothing to act against. We should feel an equal Pain at all Times, and in all Parts of our Bodies, were it not for these: The Repellency of the external Air has no Share in this. When the Glass from which the Air is drawn out, is of an irregular Figure, it is shivered to Pieces

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Pieces in an Inſtant *. When Men dive to ſuch Depths in the Sea, that the internal Particles of Air are crowded into half the Room, they feel great Pain. This is confirmed likewiſe from what happens in the Diving-Bell: But theſe Things would require more Time and Words.

*M.* Nay, *Philon*, I am now more than content to leave you: You talk away ſo faſt, that you are quite out of my Sight.

* When the Air is exhauſted out of the *Glaſs Receiver*, there is a prodigious Preſſure on all the Parts of it quite round. The mutual Repulſe between the Particles of the external Air does not keep off this Preſſure, or form an artificial Vault to preſerve the Glaſs. It bears this Preſſure by the Advantage of its Figure; as an Egg, preſſed equally at both Ends, bears a great Force. Our Bodies therefore ſuffer a Preſſure at all Times equal to what the exhauſted Receiver does. And neither the Figure of our Bodies, which is conſtantly changing while we move, or breathe, nor the firm Texture of our Fleſh, is fitted to bear this conſtant and vaſt Weight. And though either of theſe were the Cauſe, we ſhould nevertheleſs feel always an exceſſive Pain. It muſt be a Spring therefore, both more powerful and artful, which counter-acts this Preſſure, and prevents the fatal Effects it would otherwiſe have. And this Spring can be nothing but the Particles of the Air itſelf in all Parts of our Bodies, as was ſaid. It is impoſſible to reflect on this without Amazement!

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*What must have been the Consequences if the Moon had moved in a Plane crossing the Ecliptick, or Plane of the Earth's Orbit, at right Angles. That our Earth is a Moon to its own Satellite, appearing to her near* 16 *Times larger than the Sun himself, and thereby throwing on her a vast Gleam of Light.* Jupiter *appears to the innermost of his Satellites* 1600 *Times larger than the Sun does to us; and* Saturn *more than a* 1000 *Times larger to his nearest Satellites: They must therefore throw a prodigious Splendor on their own Moons. That the Plants both Primary and Secondary are thus carefully illuminated, shews they are not empty Seats; but designed for Habitation: For* Light, *in the Nature of Things, answers to* Eyes. *A skilful Artist could not design that which is more noble for the Use of what is of an inferior Nature. The whole material Universe was therefore made for the Sake of Rational Beings. That our Sun at the Distance of* Sirius *or* Arc-

turus *would appear but like one of the fixed Stars, and the ſolar Planets be quite abſorbed by the immenſe intervening Space. The great centrifugal Force on the larger Planets a Relief to their Inhabitants, as ſuſpending a conſiderable Part of their Weight on theſe vaſt Bodies. The Denſity of thoſe great Bodies wiſely contrived in being leſs than in ſmaller Bodies, upon this Account. An eaſy Way to calculate their Quantities of Matter and Denſities.*

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CXVIII. *P.* YOU muſt have grown familiar with the Planets and their Satellites, *Matho*, if you have paſt all your Time, ſince I ſaw you laſt, in the Regions above.

*M.* Sometimes above, and ſometimes below; but Familiarity, you know, is not ſo ſoon contracted in a ſtrange Country: Beſides, you may eaſily gueſs from the Heads of our laſt Conference, that my Buſineſs in thoſe Places was both various and difficult.

*P.* All is well now I hope?

*M.* All is ſo well, that I have a tolerable Notion of what we were then upon: But other Things ſtill occur which puzzle me.

*P.* It muſt be ſo with Beginners, till they have gone through the whole Scheme, and ſee

see the Consistency of one Part with another. But what are those Particulars that puzzled you most?

*M.* Before we speak of any Thing else, I must acquaint you, that an Expression you dropt at our last Meeting has exercised my Thoughts ever since.

*P.* What was it?

*M.* When we had observed, that the shortening the Distance between the Sun and Planets seemed by all Means possible to have been studied by the great *Architect of Nature*, and had talk'd of the Number of Bodies that compose the Solar System, you added, that all the Planets revolved about the Sun nearly in the same Plane; but that there were other Bodies, more in Number, which traversed the System all Manner of Ways. This, as I thought, you seemed to say, with a View to prevent an Objection, namely, Why the Sun might not have been beneficial to more Bodies, which might have revolved about him crosswise, or in a Plane crossing the other at right Angles? This brought to my Remembrance a Particular you hinted at long ago, when you seemed to conclude (from the Motion, I suppose, of some particular Bodies,) that the Attraction of the Sun reached a great Way into the Regions above

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*Saturn*, or between his Orbit and the fixed Stars. You awakened my Curiosity then, and have never satisfied me since; wherefore I beg you would inform me, what lyes concealed under those distant Hints.

*P.* When I have told you all I know concerning these Things, you will hardly think it worth your While.

*M.* But pray acquaint me with it, whatever it be.

*P.* If there be any Thing else you would discourse of, let us speak of that; and I shall readily inform you of what I know about those Matters, if an Opportunity should offer naturally.

*M.* Next then, with Respect to the Planets lying all in the same Plane nearly, (namely, that of our Ecliptick) I was trying to find what would have been the Consequences, if the Orbit of our Moon, for Instance, had lain in a Plane crossing the Plane of the Earth's Orbit at right Angles: But I could neither imagine the Case exactly, nor find out a Reason why it might not have been so in Fact.

*P.* It is enough in such Cases, *Matho*, that we see the present Disposition wise and regular; nor are we to imagine that we can come at the Knowledge of, or discover all the Reasons why Things were ordered so. *That*, as we

we have obſerved, may lead us into fatal Miſtakes. Ninth Conference.

*M.* I remember well enough the impious Notion, That one might have taught the Deity how to mend his Work.

*P.* We plainly ſee great Inconveniencies from ſome Diſpoſitions, differing from the preſent, that were equally poſſible: This ſhews us the Kindneſs and Wiſdom of the Creator, in the preſent Order and Motions of the heavenly Bodies. But ſuppoſing other Diſpoſitions might, in ſome Reſpects, have been equally advantageous for us; What then? We have nothing either to complain of, or carp at, becauſe the Deity hath choſen one of two Ways which were equally proper. And yet in the preſent Caſe, it is certainly more orderly and beautiful, that all the Bodies in the Syſtem ſhould lye in the ſame Plane, and move the ſame Way (according to the Order of the Signs) as it were in concentrical Circles; than that their Orbits ſhould have lain acroſs each other, and taken up the whole Space; though we ſhould not know for what other Purpoſe the Creator may have reſerved it free.

*M.* All this I agree to: Yet there is no Harm in endeavouring to conceive what Appearances would have been, had the Planes

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of the Moon and Earth's Orbits been at right Angles to each other.

CXIX. *P.* That might have been many different Ways. Had the common Section of the two Planes always paſſed through the Center of the Sun, the Moon would then indeed in every Revolution have been in Conjunction with, and Oppoſition to the Sun, as now: As alſo this Plane lying through the Sun and Earth, ſhe could never have been before, or behind the Earth in its annual Courſe, but ſtill equally advanced with it. Thus far you conceive?

*M.* Eaſily; for this Plane ſtanding erect above the other, like the Leaf of a Book, muſt have moved round as the Earth moved, ſo as to paſs always through the Centers of the Sun and Earth: But ſtill we ſhould have had our full and new Moon regularly as at preſent.

*P.* Hold a little.—Then you will allow, ſince this Plane ſtood erect above the other, like the Leaf of a Book, that the Way of the Sun and Moon muſt have lain perpendicularly to, or acroſs, each other?

*M.* Right; for then the Moon muſt have come over our Heads from North to South, or from South to North at leaſt.

*P.* She

*P.* She must certainly have passed through the Poles of the Ecliptick; and consequently, through or near the Poles of the World.

*M.* Let me consider this Circumstance, —I see the Plane of her Orbit must always have passed through the Poles of the Ecliptick;—And since our elevated Pole always points to the North, her Plane must have passed through the Poles of the Equator too, when the Earth was in the Solstices; for passing still through the Center of the Sun, it must then have lain directly South and North. And at all other Times it must have passed a little besides the Poles of the World.

*P.* Then the diurnal Rotation of the Earth could not have caused the Moon to rise and set to us every Day, as she does now; for when she was about the South Pole, we could not have seen her for many Days, more than now we see the Southern Constellations, which never appear above our Horizon. And besides, she must have lingred long about the gloomy Horizon, either in coming in, or going out of Sight, having but twelve Degrees of meridian Altitude the first Day of returning from the South, and twenty-four the next.

*M.* I was not aware of this. It is strange enough. All the Time likewise she should be about the northern Parts of the Globe, she

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muſt be hid to thoſe lying on the other Side the Equator; and the moſt conſtant Part of her Light muſt have been ſhed over the frozen Regions of the Earth, where there are few Creatures, at leaſt rational Inhabitants, to perceive the Benefit of it. This muſt have been a palpable Miſcalculation, to make the Light of the Moon take a different Courſe from the Light of the Sun, and ſo leave the populous and habitable Parts of the Globe worſt provided for.

*P.* There is ſtill another Inconvenience, not leſs than this: For ſince the Moon muſt always have moved upon (or near) a vertical Circle, paſſing through the Center of the Sun, ſhe muſt for half of her menſtrual Courſe have come to our Meridian almoſt at the ſame Time with the Sun, or about twelve o'Clock of the Day: That is, our Moon-Light muſt have happened, for the half of her Revolution, by Day; when it could not have been perceived, nor done us any Service.

*M.* It muſt indeed have been ſo, ſince the Half of that Circle muſt have come above, or fallen below our Horizon, nearly with the Sun; which would have been a diſadvantageous Change to us in Point of Light and Variety.

*P.* Things

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*P.* Things would have been different from what they are in most other Respects: Our periodical and synodical Months would have been the same; and the Tides must have swelled for some Days together about either Pole, once a Month, without a Tide on the opposite Part of the Globe, as now; and there must have been an Eclipse of the Sun every Conjunction, and of the Moon every Opposition.

*M.* I understand; it must have been so, because the Plane of the Moon's Orbit passed through the Centers of the Sun and Earth. ——And these several Circumstances may, I think, suggest to us the Inconveniencies we should have suffered, if not the Moon, but the Earth itself, had thus moved from North to South, instead of moving from West to East, which certainly was not impossible.

*P.* That the Equators of the diurnal Motions of all the Planets were nearly obverted to the Sun, was Matter of Choice, and not of Necessity. Had the Way of the Sun lain through the Poles of the Earth, as you suppose, the Consequences must still have been more inconvenient.

*M.* We never consider these Cases as possible; and hence it is that we never contemplate the Wisdom and Kindness of the Deity in the present Constitution. *P.* I

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*P.* I am perfectly charmed, *Matho*, with your pertinent and rational Reflections: The greateſt Philoſophers loſe the beſt Part of their Pleaſure ariſing from the Study of Nature, for Want of ſuch Obſervations.—

*M.* The Conſequences of this Suppoſition I ſhall endeavour to find out by myſelf, ſince you have put me in the Way: But you ſaid the Plane of the Moon's Orbit might have lain acroſs the Plane of the Earth's Orbit many different Ways.

*P.* It might not have lain through the Sun, but parallel to his Diſk, or at right Angles to itſelf in the former Poſition: And then it muſt alſo have gone through the Poles of the Ecliptick, and thoſe of the Equator likewiſe in the Equinoxes.

*M.* It muſt, as lying then directly North and South; or being every where at right Angles to itſelf, as in the former Suppoſition.

*P.* In this Caſe the Moon would ſometimes have been before the Earth in its annual Courſe, and ſometimes behind it, as at preſent; but could never have come into Conjunction with, or Oppoſition to the Sun, but have always kept at an equal Diſtance from him.

*M.* This Suppoſition is, I think, ſtill worſe than the laſt, ſince the Moon then muſt

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not only have spent a good Part of her menstrual Revolution about the Poles of the Globe, but could never have shone upon us with her full Lustre, as never coming to an Opposition with the Luminary from which she borrows her splendor.

*P.* And worse likewise, in that being now attracted by the Sun and Earth in two different Planes, her Motion must have become quite perplexed and irregular.

*M.* Pray help me to understand this?

*P.* You know the Plane in which she is now supposed to move, standing erect, like the Leaf of a Book, to the Plane of the Earth's Orbit, and not passing through the Sun; his whole Force must then have been exercised to bring down that Plane nearer to the Earth's; and that on whatever Side of the common Section of the two Planes she was.

*M.* I conceive it; in the last Supposition, where the Plane of her Orbit passed through the Sun, he must have accelerated her in her Course, but could not have drawn her out of the Plane in which she moved; whereas here the Lines by which she is attracted to the Sun and Earth, could never be in the same Plane, except when she was in the Intersection of both Planes: Which must make her dip, or move in no certain Plane. And as she would

be

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be drawn forward or nearer the Sun, the farther ſhe moved from the common Section on either Side, we ſhould ſtill loſe more of her Light.

*P.* You hit the Caſe perfectly: She could never be attracted by Lines in the ſame Plane, except when in her *Nodes* (as they are called;) and a ſmall Digreſſion of this Sort at preſent cauſes a conſiderable Irregularity in the Moon's Motion.——And, as I ſaid, there are innumerable other Poſitions between *theſe two*, in any of which the Plane of the Moon's Orbit would have been erect to that of the Ecliptick: But as they had been near the one or the other of the two Poſitions we have ſpoke of, ſo they muſt have participated of the Diſadvantages proper to either the firſt or the laſt.

CXX. *M.* You have now, *Philon*, been better than your Word. I not only myſelf underſtand the Beauty and Uſefulneſs of the preſent Diſpoſition, but could even ſhew to another the Inconveniency and Loſs we ſhould have ſuſtained, had the Plane of the Moon's Orbit croſſed that of the Ecliptick. And the ſame Reaſoning ſeems to be applicable to the Moons of other Planets, which muſt have been leſs carefully provided for, had the Planes of their Satellites lain acroſs the common Plane. *P.* There

*P.* There is all the Parity of Reason between their Case and ours, that can be between two Things of the same Kind.

*M.* From this notable Contrivance then, as well as from all the solicitous Provision we observed to be made before, it seems to follow, that the Use of the secondary Planets is only to reflect the borrowed Light of the Sun upon their Primaries.

*P.* That would be too rash a Supposition.

*M.* Pray wherein does the Rashness of it consist?

*P.* Our Earth performs the same Service to the Moon as the Moon does to it; or rather a great Deal more, since it reflects upon her about fifteen Times a greater Light than it receives from her: Yet no Body would say, that it was the only, or the principal Use of the Earth to reverberate the Sun's Light, in Order to illuminate the Moon.

*M.* That Assertion would be both false in Fact, and absurd in Reason. The Earth's being a habitable Globe is certainly the principal Design of it: And if it illuminates the Moon, it does that only as an accessory End, without Prejudice to the principal Use. But pray is our Earth *a Moon* to its own Moon?

*P.* Not to stand on the Novelty of the Expression, it is in Effect a Moon to its own

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Satellite: For since both Bodies are dark, or untransparent, there is the same Necessity for their reflecting the Light of the Sun on each other mutually; but the Earth reflects it much more copiously on the Moon, as being by far the greater Body. Which is manifest from bare Inspection; for a little after the Conjunction, the Part of the Moon, not yet enlightned by the Sun's Ray, becomes conspicuous to us by the Light reflected on her from the Earth.

*M.* I have in Truth observed it very distinctly; and from her Appearance at that Time there seems to be a good Degree of Light reflected on her: For I have perceived it even before our Day-Light was quite gone.

*P.* You may consider what Effect the Moon-Light would have, if it became 15 or 16 Times brighter; for such is the Moon-Light of the Moon, if I may so express it: And if you can read a small Print by our Moon-Light, what might you do there?

*M.* Fifteen Times our Moon-Light would make a Kind of Day-Light, I fancy; and we might travel, and do all Manner of Business by it, as conveniently at least as now in gloomy Weather.

*P.* The Earth, *Matho*, must appear there by Night a Globe near sixteen Times larger than

than the Body of the Sun himself; and therefore must throw a vast Gleam upon a Spectator in those Parts. Ninth Conference.

*M.* You mean, *by Night* at the Moon, and not by Night with us.

*P.* Your Correction is just; that is my Meaning

*M.* This must be a fine Sight surely, to see a Moon so large! But pray, as we perceive their Moon-Light, or the Light reflected from our Globe on them; could they perceive our Moon-Light, or the Light reflected by the Moon on our Earth?

*P.* I do not think they could; for if their Moon-Light were but a fifteenth Part of what it is, we could hardly perceive it at this Distance.

*M.* I designed to have asked you almost every Time I came here, after our first Meeting, how it comes to pass that the Moon appears in such various Forms: But from what has been said just now, and at different Times before, I think I almost understand the whole Affair, without giving you farther Trouble.

*P.* It sometimes so happens that, by reflecting on a Subject we come to have right Notions of it, without a formal Enquiry: But pray, what are your Thoughts of the various Appearances of the Moon?

*M.* Being

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*M.* Being an opaque Body, and therefore neceſſarily reflecting the Sun's Ray, ſhe muſt appear of different Forms to us, as the Hemiſphere enlightened by the Sun, is more or leſs turned to us. Therefore in the Conjunction ſhe is quite inconſpicuous, except perhaps by appearing on the Face of the Sun in an Eclipſe, as a dark Circle: In the Oppoſition ſhe muſt appear full, for her Side, to which it is then Day, is expoſed to us; and between *theſe two* ſhe muſt put on all the intermediate Appearances. I likewiſe eaſily conceive from this, why before and after the *Change*, her Horns are turned contrary Ways, ſtill from the Sun, to wit; and her luminous Edge towards him; for her enlightened Half is then going out of, or coming into our View.

*P.* You are perfectly right. I had prepared for you this Figure of her different *Phaſes*, which can be of little other Uſe to you now, than to ſhew you that the Earth puts on all the ſame Variety of Appearances to her, as ſhe does to it, but in a contrary Order.

*M.* Pray let me conſider it in that View. —I underſtand it eaſily: When we have the new Moon, the Earth muſt appear at the full to her; for her dark Side being then towards

wards us, it is Night there. As her Light increases to us, ours must decrease to her, by being carried more towards the dark Side of the Earth, and so turning her own illuminated Half to us; till she comes to the Opposition, and shines full on us, when the Earth must be quite darkened to her, unless perhaps in the Conjunction it comes over the Sun, and wholly covers him.—O right! I see now that the Earth must appear a much larger Body at the Moon, than the Sun himself, when it not only covers him wholly, but hides a great Space of the Heaven round about him. I see now more clearly what you shewed me before, That she takes a long Time to wade through the Shadow of the Earth, which is, even there, near four Times broader than herself. Well, I am delighted with all this, it is so plain, and at the same Time so agreeable too.

CXXI. *P.* A Spectator at the Moon must also enjoy a pleasing Spectacle, *Matho*, in beholding the Conversion of our Earth on its Axis in four and twenty Hours.

*M.* How would that appear to him?

*P.* By Means of this Rotation, he would be furnished with a constant Variety of Objects on his Moon, offering themselves to him

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ſucceſſively. Our *Seas* and *Continents* would there be ſeen from a right Point of View, and be remarkably diſtinguiſhed by a different Brightneſs of Colour. The Water, you know, drinking up the Rays, reflects but few of them comparatively; the Parts of our Globe therefore covered with that Element, muſt appear darker: But the ſcorched Plains of *Africa*, and thoſe Countries that lie under the Equator, muſt have a ſtrong Splendor.

*M.* This muſt certainly be very entertaining. *Madagaſcar*, *Borneo*, *Sumatra*, and the other Iſlands of that Tract, muſt make bright Spots amidſt the Ocean; while the *Mediterranean*, the *Euxine*, and *Caſpian* Seas, by their Darkneſs, ſet off the Luſtre of the neighbouring Continents. I cannot help thinking that a View of our own Globe from ſuch a Diſtance muſt be very agreeable. Twelve Hours muſt change the Scene to a Spectator at the Moon, from *Tartary* and *Aſia* to the two Continents of *America*. He could not help being ſurprized, I fancy, with the narrow ſhining *Iſthmus* that joins them together. He would likewiſe ſee, I ſuppoſe, Tracts of Land, which we ourſelves have not yet diſcovered, or know only a little of their Coaſts.

*P.* He would certainly ſee ſome Parts of our Globe which we never ſaw, nor perhaps

ever shall see. For while the Earth, in its annual Course, turned its North and South Poles alternately to the Sun, he must perceive the *vast circumpolar Regions* quite unknown to us. Ninth Conference.

*M.* From all these Particulars I am satisfied, that the Earth must make an entertaining and noble Appearance at the Moon.——

*P.* But if you go on to consider those larger Bodies, *Saturn* and *Jupiter*, they make still an incomparably more glorious Figure to their Satellites: each of them appearing some hundred Times larger than the Sun does to us, and many thousand Times larger than the Sun appears to themselves.

*M.* Let me intreat you to shew me how this is.

*P.* As the Matter is become quite easy to you now, there is no Occasion for Intreaty. *Jupiter*'s Disk is in Reality a hundred Times larger than that of the Earth; and the innermost of his Moons is not quite so far distant from him as our Moon is from us: Therefore he must appear to the innermost of his Moons a hundred Times larger than the Earth does to our Moon. But the Earth appears to our Moon near 16 Times larger than the Sun does to us; so that *Jupiter* appears to the innermost of his Satellites almost 1600 Times larger than the Sun does to us.

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*M.* This would be an inconceiveably new and glorious Sight in our Parts of the Syſtem!

*P.* Add to this, ſince the Sun's Diſk appears 25 Times leſs there than to us; *Jupiter* appears 40000 Times larger to the neareſt of his Satellites than the Sun himſelf.

*M.* If I did not all along perceive the Reaſons on which your Numbers are founded, I ſhould think you only deſigned to indulge me in a little vain Amuſement; but as it is, I am really convinced of the Truth of what you advance.

*P.* Theſe Numbers and Proportions are not much over nor under the Truth; but where there was nothing that required any great Exactneſs it would have been needleſs to have affected it.

*M.* Pray ſhew me next what Appearance *Saturn* makes to his Moons?

*P. Saturn*'s Diſk is 64 or 65 Times larger than the Earth's: Therefore he appears to two or three of his neareſt Satellites 64 Times larger than the Earth does to our Moon; and of Conſequence, upwards of a 1000 Times bigger than the Sun appears with us. The Sun's Diſk there is near a 100 Times leſs than here. *Saturn* therefore at the Diſtance of our Moon appears about 100000 Times

Times bigger than the Sun himself does. Thus *Jupiter* and *Saturn* must appear to their Satellites, not as Moons but prodigious resplendent Orbs in the Heaven, taking up no small Space in the azure Firmament with their luminous Bodies. For on allowing *Jupiter*'s Disk to appear 1600 Times larger than the Sun's to a Spectator on our Earth, you will find that his Diameter extends to more than one and twenty Degrees in the Heavens. Ninth Conference.

*M.* I want to see this more particularly?

*P.* The Sun's mean Diameter with us is about 32 Minutes, or half a Degree and two Minutes: But the Square Root of 1600 is 40; 40 Times the Sun's Diameter therefore is about 21 Degrees 20 Minutes.

*M.* This is plain: But pray represent the Thing to my Imagination, if you can.

*P.* Twenty Degrees is about the ninth Part of a Semi-circle: So that nine such Bodies as *Jupiter* appears to his nearest Satellite must do more than reach from one Side of the Heaven to the other.

*M.* This gives me Satisfaction; and I find we have no Notion of such Luminaries in our Part of the System; for when *Jupiter* rises to his Satellites, a whole Quarter of the Firmament must seem in a blaze of Light.

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*P.* He appears leſs to the Reſt of his Satellites; but ſtill larger than any Luminary we have a Notion of.

*M.* And *Saturn*, what Figure does he make to his Satellites?

*P.* To the innermoſt of his Satellites he appears of incredible Bulk; bigger than *Jupiter* himſelf to the innermoſt of his; if it were worth the while to be particular on theſe Things: But at the Diſtance of our Moon his Diſk is about 1024 Times larger than the Sun's to us. The Square Root of this Number is 32 nearly; his Diameter therefore at this Diſtance is about 17 Degrees; or ten and a half ſuch Bodies as he, placed by each other's Sides, would extend over the whole Heaven, from Eaſt to Weſt.

CXXII. *M.* All this is ſo new and ſurpriſing to me, *Philon*, that I cannot ſufficiently expreſs my Admiration of it. You convinced me before that the *Heaven* of *Jupiter*, or *Saturn*, was beautiful and glorious: But this View of the *Heaven* of their Satellites ſurpaſſes the Force of Imagination. For we may add to this, I preſume, that every Satellite enjoys a fine Proſpect of its neighbouring Moons, which muſt appear to it, as well as to their primary Planet.

*P.* It

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*P.* It must be so, since they are reasonably supposed not to be less than our Earth: If so, when one of them is in the Opposition, or near it, and the *next inferior* ascending towards it; the higher must appear to the lower, larger than our Earth does at the Moon. But it would be endless to pursue the several Appearances they make to each other.

*M.* Pray what can be the Use of this Profusion of Light, thrown on these secondary Planets, even by their Primaries themselves? Or of that Light reflected on our Moon by the Earth?

*P.* What should the Use of it be, but that they may have Light enough to see to keep to their Orbits regularly? Otherwise, revolving in those vast, pathless Spaces above, they might have missed their Way.

*M.* Ah, *Philon!* can you find in your Heart to joke at this Rate, on such a Subject! Let me beg of you to tell me what can be the Use of all this Light? For it is certain, that a Thing thus laid out with so much Study, and executed by such mighty Contrivance, cannot be without Design, and for no Purpose.

*P.* I wonder, *Matho*, you did not first ask me, what was the Use of all that Light, shed on the primary Planets by their Secondaries?

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ries? Or by the Sun himſelf? Can this be without Deſign, more than the other?

*M.* What ſurpriſed me moſt was, That the primary Planets ſhould be *Moons* to their own Moons: This made me aſk the Queſtion at firſt; though I find I am ſtill as ignorant of the Queſtion you put, and which I ought more naturally to have aſked in the firſt Place.

*P.* Can the Light then ſhed on the greater Planets be without Deſign, more than that ſhed on the *leſſer?*

*M.* Moſt undoubedly it cannot. The *Almighty Architect* would never have made uſe of ſuch laborious Methods as we have ſeen, to furniſh the moſt remote Bodies of our Syſtem with ſuch Variety of Light, if Light had not been abſolutely neceſſary to them.

*P.* And what is it in the Nature of Things, that can make Light abſolutely neceſſary to thoſe great Bodies lying at ſuch a Diſtance from the Sun; and with which you ſee they are ſo wonderfully ſupplied?

*M.* I cannot indeed tell; but expect that you ſhould anſwer this Queſtion yourſelf.

*P.* And yet I ſhould think that ſuch a Queſtion were not difficult to be anſwered. Tell me, What is the Uſe of the Light of the Moon to our Earth?

*M.* This

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*M.* This I can easily answer. The Moon illuminates the darkened Part of the Earth in the Sun's Absence; she directs the Traveller in his Way, and the Seafaring Man in his Course by Night; and divides our Time to us in a different Manner from what the Sun does.

*P.* Very good: But would the *Terraqueous Globe* itself (I mean the *Mountains, Fields, Rivers, Ocean,)* stand in need of Light, if it were not inhabited? Or what is it in the Nature of Things, for which Light is appointed; and to which it answers? To Eyes, or to Ears? You see we stand in need of Light in our Houses; but could there be any Necessity for these, if the Houses were uninhabited; if no Body dwelt in them?

*M.* It is enough, *Philon*; pardon my want of Thought. I ought to have been upon my Guard, when you began with your ironical Way of Joking. You mean, that all the other Planets, as well as our Earth, are habitable Globes, and the Residence of such to whom the Light of the Sun may be serviceable; or, to speak more justly, to whom it is altogether necessary.

CXXIII. *P.* Why was a Sun necessary at all in the System, *Matho*, if not upon this Account? Why might it not have been a dark, a torpid,

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a torpid, and a motionleſs Abyſs? Or why was the Frame of Nature built at all?—— Theſe are Queſtions we ſhould know how to anſwer, if we are capable of anſwering any thing; if we know whether we were made by *Chance*, or *a deſigning Cauſe*. Every Body will own that the Syſtem required a Sun, regular Motions and the preſent Contrivances; becauſe it was to be inhabited.——Right: But was it to have a Sun, and theſe Conveniencies, that only the hundredth Part of it, nay that leſs than the hundredth Part of it, ſhould be inhabited? Was it to have theſe Contrivances, that it might be uninhabited even where they ſeem to have been moſt ſtudied? For, if we may compare the Works of the Creator among themſelves, the Contrivances for illuminating the ſuperior Planets are, without Controverſy, extremely more ſtudied than in the lower Parts of the Syſtem. Call to Mind again the Heavens of *Jupiter* and *Saturn*, what bright Parts of the Univerſe thoſe are; though ſo far removed from the Sun. Theſe Bodies, you owned, appear to each other vaſt Globes of Light, far exceeding the Notion we have of *celeſtial Luminaries*. If we ſuppoſe a Spectator brought from thence to our Regions, he muſt think he were conveyed to a dull and languiſhing Part of Nature.

*M.* You

*M.* You have shewn me that Particular to Satisfaction: But I ought to have foreseen this Consequence long ago, when I observed such various and artful Provision made for throwing Light on all the Parts of the planetary World; when I beheld the Planets placed, not one without another, but five or six of them so disposed at the same Distance from the Sun, that they might all enjoy his Light equally, and reflect it likewise on each other mutually. This is such an expressive Artifice, as is not easy to be mistaken: Otherwise what Difference would there have been, whether the Planets had been placed far from, or near the Sun; were they not to have been replenished with Inhabitants, who might perceive the Advantage of the Light? Or what needless Work had it been, so carefully to provide the Comforts of *Living Beings* for Things void of Life? Ninth Conference.

*P.* This Consequence seems to be implied, *Matho*, from the very Time we understand the Sun to be such a vast Body, merely upon the Account of the Planets. He was to keep them near him by his Attraction, and to cherish them by his Heat and Light. But to cherish what? Some mighty Globes of Marble, for Instance, some huge Masses of dead Matter! No Reason at all would be better than this.

*P.* I

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*M.* I confeſs I ought to have conſidered the Work in this View, when firſt I underſtood that the Planets were made to revolve about the Sun by ſuch wonderful Power; that they might move without changing Diſtance from their Center of Heat and Light: And when I firſt ſaw that they rolled round on their Axes, that they might enjoy the Light and Shade alternately. No Eyes could bear a perpetual Splendor. But above all, I ought to have foreſeen this Deſign of the Work, when I ſaw Planets revolving about other Planets, and thoſe revolving about the Center of Heat and Light! This could not be a mere Flouriſh of Skill in the *Almighty Architect*; an ambitious affected Ornament, that ſerved only to ſhew what he could do when he had a Mind.

*P.* You are grown a powerful Orator for this Side of the Queſtion, all of a ſudden, *Matho.*

*M.* I am ſerious in what I ſay, and do not talk thus out of an Affectation to be thought to underſtand a Thing, before I ſee it. When I reflect on all we have ſaid from the Beginning, it appears to me conſiſtent in this Senſe; but without this it ſeems ſcarce to have a Meaning: Every Thing indeed confirms it, and nothing, ſo far as I know, makes againſt it.

it. For why should our Earth alone of all the Planets be furnished with Inhabitants; since it is neither the greatest, nor the innermost, nor the outermost, nor the best furnished with Light, or with Variety of it, to receive them: I say, why should it of all the Planets be graced with Inhabitants, while others, either larger, or nearer the Source of Heat and Light, are left empty and desolate? It vanishes long before we come to *Jupiter* or *Saturn*, the least of whose Satellites are probably as large. It is placed, suppose, at 21000 of its own Semi-diameters from the Sun: What is the Meaning then of *Jupiter*, a much larger Body, placed at 5 times that Distance? Or of *Saturn* placed at near 10 times that Distance? Or of *Venus* placed at 1500 such Diameters from him? Could not this Earth have rolled round the Sun, and been inhabited, unless it had been attended with those larger Bodies, rolling likewise round him without Inhabitants?

*M.* I think therefore, *Philon*, we should never look to the Heavens, and those mighty Bodies that roll round with us; nor consider that their Motions are governed by the same common Laws, nor suffer our Thoughts to rise above the Surface on which we tread; unless we come into this Opinion: For it appears

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pears to be *that*, which can only ſolve a thouſand Doubts in our Mind, and free us from a thouſand Abſurdities, which we muſt otherwiſe entertain concerning the *great Architect* of the World.

*P.* There ſeems in Truth to be no Medium, between remaining quite ignorant of all the Miracles of Power, and Wiſdom, which appear in the Heavens, and coming into this Notion: And on this Account it was, that Men came into it, as ſoon as they began to compare this Earth with the other great Bodies in Nature, and found that it was but as a Point in Compariſon of the Univerſe. But

CXXIV. Since you have ſo little Doubt of the primary Planets being habitable, what do you think muſt be the Uſe, or the Deſign, of that more copious Light reflected on the Moon by our Earth; or by thoſe larger Bodies *Jupiter* and *Saturn*, on their Secondaries?

*M.* I ſhall not readily forget theſe laſt; and as more ample Proviſion hath been made for them, than for the primary Planets themſelves; they cannot be idle *Phænomena* in the Sky, to amuſe——I know not what Beings, if none are there: But the different Abodes rather of ſome ſort of living Creatures: For thus

thus the Convenience *of more* is consulted, as I remember you observed some Time ago. Ninth Conference.

*P.* Certainly the System is then of more Use; nor can it be construed a Blunder, or Misunderstanding of the Design, if the Works of the *Author of Nature* are not idle, or employed to small Purpose.

*M.* It is rather true on the contrary that, the more useful they are, the more skillful they must be accounted. *A large Design, with small Convenience* shews that the Artist was not Master of his Business.

*P.* You express the Case with Propriety. It might be said that our Seas are large; but we have seen that they are referred to the Uses of Habitation; and besides they are the Nursery and Seat of numberless Species of living Creatures: Our Mountains are wild; but they are notwithstanding a continued Scene of Vegetation and Life, and not useless Deformities on the Face of the Globe.

*M.* And by a Parity of Reason, these secondary Planets certainly answer a more noble End, if they are equally the Seats of living Beings, than if they only reflected the Light emptily, on other empty Globes. Without this we cannot imagine to what Purpose such vast Spheres should bandy the Sun's Splendor from one to another, and keep up an *eternal Dance*,

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*Dance*, unperceived by any Creature, unleſs perhaps by a few ſtudious Perſons here on Earth, peeping through a Teleſcope. I cannot bear to think that ſuch wonderful Sights ſhould have been ſo far removed from us; if there were none elſe to admire them.

*P.* The Thought indeed ſhocks common Senſe. But it is likewiſe of Conſequence in this Affair, *Matho*, to conſider that on the Surface of the Moon (the neareſt of thoſe Bodies to us) as ſeen through the Teleſcope, frequent *Mountains*, higher than ours, *Rocks*, *Lakes*, and Seas are diſcovered; all which ſhew a Planet not unfit for Habitation, but diſpoſed like to our Earth.

*M.* Something like this is perceived even by the naked Eye.

*P.* Here is a pretty exact Figure of the Moon, *Matho*, as obſerved through the Teleſcope.

*M.* Pray let me look at it. There is indeed a great Inequality on her Surface here, and Variety of Light and Shade; for ſome Parts are very dark, and others reſplendent. I don't know whether there be ſuch a Difference of Appearances even on the Surface of our Earth.

*P.* You cannot, unleſs you were to ſee it from the Moon.

*M.* What

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*M.* What ragged and broken Places are these, on the Edges of these lesser Figures?

*P.* Consider how large these Objects must be in themselves, when they lye at near 24000 Miles Distance from us! These are *Rocks*, *Mountains* and *hollow Valleys*, which become thus conspicuous in certain Positions of the Moon, with respect to the Light of the Sun: The Tops of these Mountains appear thus by the Rays of the Sun striking on them, before the Light hath reached those Parts of the Moon's Surface, where they are situated.

*M.* Surely the Use of these *Inequalities* and *deep Shades* that appear, cannot be to reflect the Light on us: Such large Heights and Declivities seem rather fitted for the Descent of Waters, and the Uses of Vegetation.

*P.* What you observe seems of great Weight: No Body can be so fanciful as to imagine that those *dark Tracks*, and *deep Shades* are designed for the Reflection of the Sun's Rays. But it is farther observed, that these Shadows seen on the Surface of the Moon are contracted, as those Parts of her Disk are more turned to the Sun: Just as the Shadows of our Mountains become shorter, as the Sun rises higher; and quite disappear in the Height of the Day: Which shews that it is but a secondary Use of this Planet

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to reflect the Sun's Light back on the Earth. If that had been the only, or the principal Use of the Moon, she must have had a certain equable Roughness of Surface, like an unpolished Block of white Marble, for dispersing the Sun's Rays every way: But no Risings, or Inequalities, like Rocks or Mountains. But the Author of Nature, who is the *first Optician*, and knew what Effect her present Surface would have at the Earth, hath given her a Mixture of the one and the other, to answer different Ends. And hence it is that we receive great Assistance even from her reflected Light: And she receives greater from our Earth, though made unequal by Mountains and Valleys. In short, the most diligent Observers of this Planet conclude, that our Earth seen there would make just such an Appearance to the Eye, (though much larger) as the Moon does to us here.

*M.* This Point seems to be out of Doubt, unless we would insist on Proofs which cannot be had, from the Nature of the Case: For, since our Earth is an habitable Globe, and at the same Time serves as a Moon, there is certainly equal Reason for concluding, that the Globe, which serves us for a Moon, should be habitable too.—I remember you said before, that the *Arch*, which surrounds the Body

dy of *Saturn*, seemed not wholly designed for reflecting the Light on the interior Planet; since it keeps off as much at one Season, as it reflects at another: Now pray what may your Thoughts be of this singular Piece of divine Workmanship? Ninth Conference.

*P.* It is more easy (as I said then) to tell you what I do not think of it, than to form any consistent Thought about it. I do not think it the Ruins of an exterior Crust, the rest of which hath fallen down upon the Body of *Saturn*. The Dilapidation of a Planet hath to me a strange Sound; nor are Ruins wont to be so regular: Though even that would make it originally designed for Habitation. Nor can I think it is a fluid Body. It must then indeed have a swift Rotation on its Axis, to give every Part of it a centrifugal Force equal to its Gravity, and hinder it from falling down. The Time of which might easily be assigned: But I do not see why it should then be flat and broad, with the Edge towards us; it ought rather, I think, to be of a round or cylindrical Form. So that it appears more probably to be solid.

*M.* You seem inclined, I think, to suppose that this *pendulous Structure* may even be habitable.

*P.* Every Body in Nature, *Matho*, is pen-

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dulous, though in different Circumſtances from it. There is no Abſurdity in ſuppoſing it may be habitable, and ſerve at the ſame Time for ſome great Purpoſe to the Planet it ſurrounds, as well as receive Advantage from it: But the ſafer Way is to own, that it demands our Admiration, while it is beyond our Reach to diſcover the Uſe for which it was thus contrived.

*M.* Leaving this Body therefore as we found it; this I think ſeems to me beyond rational Doubt, that all the Planets, primary as well as ſecondary, are the Abodes of ſome ſort of Inhabitants or other.

CXXV. *P.* Conſider then in the next Place, *Matho*, whether a ſkillful Artiſt could deſign that which is of greater Dignity, only for the ſake of the inferior Part of his Work?

*M.* Here, *Philon*, I fancy I gueſs what you intend by this Queſtion; and the Anſwer is obvious: A ſkillful Artiſt could neither deſign ſuch a Blunder; nor could a fair Enquirer in the preſent Caſe imagine, that *Man* was made for the ſake of the Brutes, nor the inferior Animals for the ſake of the Vegetables, nor the yearly Production of Vegetables for the Relief and Comfort of the Soil on which they grow. This would be to turn the Bottom

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tom upward, and invert the Order of Things. I have not forgot what you shewed me concerning the *rising Scale* of created Beings. This *Gradation* is the Voice of Nature, as well as of Reason, and confirmed by constant Observation of the different Species of Things on and about our Earth. The Relation and Aptitude of one Thing to another, where the *Unity of Design* appears through an infinite Variety of Particulars, always rises upward.

*P.* You resume the Substance of what we then said, in a just and expressive Manner. ——For whose sake then, tell me, was this Earth formed, furnished out, and placed to revolve among the rest of the Planets; for the sake of the rational, irrational, or vegetating Beings on it?

*M.* This Question is so plain, that I know you will hardly expect I should give you a direct Answer: But you mean that the other Planets, as well secondary as primary (which appears now to be rather a nominal Distinction, than to imply any real Difference of their Use and Nature) could not have been made on the Account of brute Animals, which can neither conceive the Beauty of the Work, nor acknowledge the Benevolence of the Creator, nor have their Nature improved by the Power and Wisdom displayed in the Order and Variety of the Parts.

 *P.* Undoubt-

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*P.* Undoubtedly, *Matho*, the ſame Reaſon holds, and is indeed ſtronger with Reſpect to the Reſt of the Planets, than to our Earth. For if it would have been unſuitable to have peopled a leſſer Planet only with brute Beaſts, it had been ſtill more abſurd to have made the Syſtems of *Saturn* and *Jupiter*, only for the ſake of irrational Animals. Wherefore a *nobler Gueſt* was to be placed in thoſe magnificent Globes; who, though perhaps not reſembling us in all Particulars, may nevertheleſs be endued with the ſame rational Nature, and that poſſibly in greater Perfection, in Proportion to the Dignity of thoſe nobler Manſions. ——It is ſtrangely inconſiſtent with Reaſon, to imagine this vaſt Structure of the Univerſe to have been raiſed up in immenſe Space only to be the Seat of eternal Silence and Solitude; the ſtarry Worlds on high unfolded, the harmonious Motions of the Planets contrived, and all adorned with amazing Splendor and Brightneſs, only that wild Beaſts might have a more convenient Retreat!

*M.* Ah, *Philon!* name not ſuch a grievous Abſurdity! It ſhocks Nature, and affronts the *Infinite Reaſon.*

*P.* Wherefore, I ſay, a *more divine Nature* than ſuch Kind of Beings, was wanting to complete the Deſign; a Nature ſanctified with

with Reason, aspiring after the endless Improvement of the rational Faculties, searching into the necessary and eternal Reasons of Things, itself desirous of, and designed for Eternity. For Reason most plainly denies that a rational Nature should ever die. Ninth Conference.

*M.* You carry me irresistibly along with the Strength and Pleasure of the Argument. It must be allowed that God, who is the *Infinite Reason*, cannot but delight in rational Works; nor can he be the Creator of other Things, except so far as they are subservient to these. It is thus the Government of Reason is known from the Temerity of Chance.

*P.* Your Inference is solid, and of the last Importance: And from thence it will follow, that he could only have been the Creator of inert Matter, or of a sensitive and irrational Nature, so far as they regard something higher. And wherever that, which was made for the sake of another, is, there that, for whose sake it was made, must be.

*M.* How vain and peevish is *Man*, who makes himself the only Favourite of Heaven and claims to himself alone the Care of Omnipotence! as if the Kindness shewn him supposed a Neglect of all other Things; or, as if he were injured, unless the Universe were an *infinite Waste* to please him. How much

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better were it, as Modeſty requires, to acknowledge the other Bodies in the Univerſe equally dignified by *Reaſon*, with this Seat of ours!

*P.* I believe, *Matho*, you have ſaid more than you are aware of: the Univerſe muſt be a *Waſte* almoſt infinite indeed, if the Opinion of the greateſt Philoſophers, founded on the Nature of Things, may be depended on in this Caſe.

*M.* Pray what is their Opinion? I ſhould be glad, if what ſeems ſo agreeable to Reaſon has alſo the Authority of better Judges. And it muſt, I think, appear reaſonable to every body, that the living and rational Creation ſhould be as extenſive, as the dead and inanimate Part of it; ſince it is undeniable, that the latter was made for the former. But to imagine that, while the material Univerſe is almoſt boundleſs, the rational Creation is ſo confined and narrow a Thing, that a Ship might ſail round it in a few Months, is, I'm afraid, to meaſure the Works of Omnipotence by our narrow Prejudices.——But pray go on to acquaint me with the Opinion of the *Learned* on this Head.

CXXVI. *P.* You obſerved long ſince, if the Sun were removed always farther and farther

ther from a Spectator, or the Spectator from him, that he must still seem less and less, till at length he should appear but of the Bigness of a larger Star, or even of a lesser.

*M.* ——And that at last he would quite disappear; because from the Increase of the Distance the greatest Bodies must at length escape the Sight. Nor, I presume, can any other Reason be assigned, except the Vastness of the Distance, why many Stars, which cannot be discerned with the naked Eye, become perceptible through the Telescope. And even those probably are not the most distant; for the Telescope, as well as the Eye, must have its Limits.

*P.* Surely it must. Could that Invention be brought to the last Degree of Perfection, it would, no Doubt, discover to us Stars hitherto imperceptible; since the more perfect any Instrument of this Sort is, the more of those celestial Bodies it brings within our View. It is surprising what Numbers of them have been discerned by this Means, in a Space where we see but very few, or none at all. In the *Pleiades* alone, where we can discover but six or seven, near two hundred have been reckoned.

*M.* From all this then it naturally follows, that the Distance may be so great that the Sun

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Sun himſelf could not be conſpicuous from thence.

*P.* Or any Body equal to the Sun in Magnitude and Splendor.

*M.* That is but the ſame Caſe.

*P.* Now the Diſtance of the fixed Stars from us is ſo vaſt, that the Diſtance of the Earth from the Sun is but as a Point in Compariſon of it.

*M.* This you mentioned in our third Conference, and I have thought of it frequently ſince; for it raiſed my Admiration and Curioſity; Pleaſe therefore now to ſhew me what Ground there is for that Aſſertion.

*P.* You muſt firſt call to Mind that the Diameter of the *Magnus Orbis* (as it is called) or the Earth's annual Orbit, is upwards of forty thouſand Times the Semi-diameter of the Earth itſelf, according to the common Suppoſition of the Sun's Diſtance; that is, upwards of an hundred and ſixty Millions of Miles.

*M.* Could you not give me ſome ſenſible Repreſentation of this Diſtance, as you did of the Sun's Magnitude? For bare Numbers do not ſtrike the Imagination.

*P.* I cannot indeed: All our Meaſures, and ſenſible Images are ſwallowed up here, without being known: You ſee it is more than forty

forty thousand Times the Semi-diameter of the Earth itself, which is our greatest Measure. Even the Moon's Orbit which helped you to conceive the Magnitude of the Sun, could not much assist your Imagination in this Case. Ninth Conference.

*M.* Well, go on.

*P.* Now when the Earth is in the opposite Parts of its annual Course, or hath really advanced a hundred and sixty Millions of Miles nearer some of the fixed Stars, and hath left others of them so much behind, it seems not to have changed its Place with Respect to them, nor they to have altered their Situation with Respect to each other in the least: Which could not be if this Diameter of the *Magnus Orbis* bore any assignable Proportion to its Distance from the fixed Stars.

*M.* Let me consider this a little.——If I should travel a hundred and sixty thousand Miles straight forward every Year, for a thousand Years together, and yet never perceive myself draw nearer certain immoveable Bodies that were before my Face, nor farther from others that I see left behind my Back; and if one particular Body, in all that long Journey, should still appear with the same Degree of Elevation above my Head;——I see plainly the Consequence: Those Bodies must indeed be at an inconceivable Distance from me; and the

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the Space I had travelled over muſt bear no Proportion to their Diſtance; otherwiſe they would ſeem to have changed their Situation among themſelves; as the Objects in a large plain are thrown into a different Order, while I travel through it.

*P.* You have formed to yourſelf an Idea of this to better Purpoſe than I could have done: Only this is no Fiction; you are really carried thus far, not indeed once in a thouſand Years, but twice in one Year. For, in Effect you are about the 10th of *June* a 1000 Times a 160000 Miles farther from the Northern Parts of the Heaven than you were the *December* before: And yet you perceive your Situation with Reſpect to them no Ways changed.

*M.* This then helps me to underſtand that *immenſe Triangle* you ſuppoſed drawn, of which this Diameter of the *Magnus Orbis* was the Baſe; and the two Sides meeting in the Pole of the Heavens, were yet with Reſpect to our Perception parallel. Whence we inferred that the Baſe was but as a Point in Compariſon of the Sides. The one Argument illuſtrates the other: And from hence I perceive we rightly inferred the Paralleliſm of the Axis of the Earth to itſelf, in all its annual Courſe; to which chiefly we owe our Diverſity of Seaſons.

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CXXVII *P.* From this Account then how large Bodies, do you think, must the fixed Stars be, which are thus conspicuous at such a prodigious Distance?

*M.* Vast Globes certainly; not less perhaps than the Sun himself.

*P.* There is neither *perhaps* nor *peradventure* in the Case, *Matho*, for it can be shewn by irrefragable Arguments, that were the Sun at such an immense Distance, he would not appear larger than one of those Stars: Nay, were he not a luminous Globe, he could not be seen there at all. But those Bodies are conspicuous at greater Distances, than are mensurable by the Laws of Opticks. And hence it is that the most judicious Astronomers have rightly concluded, that the *fixed Stars* are prodigious luminous Bodies, equal to the Sun in Bigness; or that they are themselves indeed so many Suns*. *M.* I

* Hinc patet Systema Planetarum circumsolarium, è fixa spectatum, visum prorsus fugere, & in idem punctum luciđum confundi cum Sole, cujus Diameter insensibilis fiet, si distinctè spectetur & orbatus Capillitio, quali fixæ Terricolis cinctæ videntur.——Ideoque vicissim Planetæ circa *Soles istos* [*fixas*; scil.] rotati Observationem nostram effugiunt penitùs. Dubium non est quin, oculo in fixa aliqua (aut Planeta circa illam revoluto) posito, reliquarum circumcirca fixarum Ordo et Constellationum Figuræ diversa sint prorsus ab illis, quæ nos spectamus; quippe cui Sol noster Stellâ fixa videtur. *Gregor. Astronom.* Lib. 6. Prop. 7. Coroll.

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*M.* I said *perhaps*, not that I doubted; for this Conclusion seems to follow from what was said just now, *viz.* That the whole Diameter of the *Magnus Orbis* is but as a Point in respect of their Distance. But why did you say, That they are seen farther than the Laws of Opticks reach to?

*P.* When they are seen through a Telescope which magnifies above a hundred Times, they do not appear bigger than at present; or rather they appear less, but better defined; the tremulous Scintillation, or Sparkling, being thus cut off. Whence it is inferred that, were the Distance between them and us but one 99th Part of what it is, we should perceive them little bigger than we do at present. And since the Breadth and Diameter of Objects decreases, as their Distance from the Eye increases; the fixed Stars (according to the Rules of Opticks) must be quite extinguished, long before the Distance were increased to 99 Times as much. Whence, were the Sun at the Distance of the fixed Stars, he would appear only as a luminous Point, without Breadth; and were he not luminous, he could not appear at such a Distance at all.

*M.* I had no Difficulty on this Head before; but what you have now added gives me still more Satisfaction. And since in the Immensity

Immensity of Space the greatest luminous Bodies must at last disappear, their different apparent Magnitudes may be owing to their different Distances; allowing they were all equal among themselves. Ninth Conference.

*P.* On that Supposition another Reason cannot be assigned.

*M.* This Boundlessness of the material Universe distresses the Imagination; and is literally inconceivable!—

*P.* If then the fixed Stars are Suns equal to ours, which can only be denied by shutting our Eyes to these Reasons; Pray for what Purpose shall we say they were created? That they might twinkle to us in a Winter-Evening through the infinite Space?

*M.* I foresee what you aim at; but go on: Their twinkling to us, whatever Pleasure it may give us, cannot be the principal Design of the Creator in forming them.

*P.* If they were solely designed for our Use, why are they so far removed from us as that we should not have the full Use of them?——Why are they *so many*, when fewer; or such *great Bodies*, when lesser Lights placed nearer to us, might have been more useful?

*M.* Do not mention such an Absurdity; no Body will so much as pretend it. What Use

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Uſe could this little Globe have had for ſuch a Number of Suns? Or how could it have borne them nearer? Shades and Darkneſs are as neceſſary to our State as Life itſelf.——

*P.* If then thoſe Bodies are luminous Globes, equal to the Sun in Splendor and Magnitude, can they ſerve for a leſs noble Purpoſe, or be of leſs Uſe in the Creation, than the Sun himſelf?

*M.* Equal Bodies muſt ſerve for equal Purpoſes; unleſs we would ſuppoſe that the *Author of Nature* wrought accurately only in our Syſtem, and looſely in all Parts of the Univerſe beſides. Which I'm afraid is the general Prejudice, in this as well as in other Caſes.——

*P.* Do you think that to an Eye placed at the Diſtance of *Sirius* or *Arcturus*, where our Sun would appear but as a luminous Point, the ſolar Planets could be diſcerned?

*M.* No; They muſt be confounded with that Point, as much (and more) as the inferior Planets, *Mercury* and *Venus* are confounded with the ſolar Rays, at the Diſtance but of *Jupiter* or *Saturn*.——From all this you infer (nor do I ſee what can be ſaid againſt it) That the *fixed Stars* have each their Syſtem of Planets, which cannot be diſcerned by us at this immenſe Diſtance; and that they

they shine to the Inhabitants of those Regions.

*P.* Perhaps they shine to none?

*M.* Yes, if Light doth not answer to Eyes; or rather if it answers to nothing.

*P.* If then, they shine to any Beings, can we imagine that they shine for the Sake of those who do not perceive the hundredth Part of them, without the Help of a Telescope, or even perhaps with the Assistance of that Invention?

*M.* That would be notably repugnant, to imagine they shine for those who do not see them. Wherefore, I say, I would not have you so much as suppose that such Use of them is pretended; since no Body, I believe, will imagine it. I readily come into your Sentiments: For, as was observed before, we must either not think upon this Subject at all, but forget that there are such Bodies in Nature; or if we reflect upon them otherwise than Children do, (who look upon the Stars as so many bright Studs, with which the vaulted Roof of Heaven is adorned) we must come into this Opinion. The Inhabitants of those Parts and we seem to be much in the same Condition. To a Spectator placed there our Sun must appear as a fixed Star, and the solar Planets be quite absorbed by Immensi-

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fity of the Diſtance: Yet it would not follow, that there was no ſuch Globe as our Earth, and that no living Being exiſted *near that fixed Star*. In ſhort, this Point can only be determined in the Nature of Things, by the Principles of Reaſon: And to reject it becauſe it cannot be aſcertained by Eye-Sight, or by travelling into thoſe Parts, ſeems equal to picking a Quarrel with Reaſon itſelf.

CXXVIII. *P.* If, *Matho*, any other Uſe of Light could be imagined, than to anſwer the Purpoſes of Eyes and Viſion, or if Eyes could belong to any other than a corporeal Nature, I ſhould not ſuppoſe that any Species of animal Creatures reſided in thoſe Parts: Or if it could be ſuppoſed that by far the greateſt Part of the Univerſe was to fall to the Share of brute Creatures (while a Point only was allotted for the Habitation of rational Beings, which can hardly be diſcerned among the other Bodies in the Creation;) I ſhould ſuſpect that only brute and ſenſitive Animals might inhabit the wide Expanſe of material Nature. But ſince theſe Suppoſitions are inconſiſtent with Reaſon, and inferior Creatures were only deſigned for the Sake of nobler Beings, I am forced into this Opinion whether I will or not.

*M.* And

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*M.* And I, on the contrary, come into it with Pleasure. I remember with what Surprize I first heard of the *Antipodes*; Inhabitants, as I thought, with their Heads hanging downward: But now I am sensible what a Void there must have been, had not our Globe been habitable quite round. It would then have served but just for half the Use it serves now.

*P.* You do not know, *Matho*, that some Centuries ago it was reckoned absurd, and little less than impious, to suppose that there were Antipodes, or Inhabitants on the opposite Part of our own Globe. This Narrowness of Thought is now laughed at as an idle Prejudice of ignorant Antiquity: But once it was a serious Affair. So difficult is it to get the better of Prejudices that have once taken Root in our Minds!

*M.* So much the earlier therefore they ought to be corrected. But in the present Case, I shall for the future contemplate the Face of the Heavens in the Night Time with more Delight, while I consider that all above me is not a wild Solitude, designed only to fatigue the Eye, and amuse us puny Mortals; but that rational Beings inhabit those Regions, and admire with us the Wisdom of the common Creator, displayed in their different

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Views of Nature: And while I reflect, that we have not paſſed the Bounds of the rational Creation, when without the narrow Limits of our own Syſtem.

*P.* You have ſeen how narrow the Limits of the Syſtem are, compared with the whole Creation: So that whatever Reaſon ſhews us that the Reſt of the Bodies in the ſolar Regions are not unfiniſhed or uninhabited Seats, muſt likewiſe ſhew us that the other Syſtems in the Univerſe (which bear an incomparably greater Proportion to them than they do to our Earth) cannot be an immenſe Deſert, nor be without Spectators of what is done there by the *Almighty Architect.*

*M.* I underſtand: The Reaſon becomes ſtill ſtronger the higher we aſcend.

*P.* If once we go beyond the Surface of this Globe on which we tread, we can ſtop no where; nor rebate the Force of the Reaſon, which ſtill becomes ſtronger, till we acknowledge the material Creation habitable throughout. Hence we muſt ſuppoſe that only a Point of the Univerſe is habitable; or that the whole Univerſe is habitable. The Argument will always return upon us, *Whereever that which was made for the Sake of a nobler Nature there the nobler Nature, for whoſe Sake it was made, muſt be.*

*M.* As

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*M.* As was said in a like Case before, it is probable the contrary Opinion first prevailed, because Men believed that the Earth was the greatest Body in Nature; that it occupied the Center of the Universe; that all Things else were created for its Sake; and that the Heavens consisted of solid Orbs, which whirled round our Globe in four and twenty Hours.

*P.* Let us only add to this, that an *universal upward* and *downward* was believed to reach through all the material World, respecting only this Earth; and I believe we have all the Prejudices on which the contrary Opinion was founded. So that whatever removes this Heap of vulgar Mistakes from Philosophy, and shews that the Earth revolves among the other Planets, and that its diurnal Rotation supersedes the rapid Motion of the Spheres; shews at the same Time the Reasonableness of this Opinion.

*M.* We ought therefore, I think, to come into it, in Consequence of having thrown off those Prejudices: unless we would be thought to have reformed our Philosophy by halves only. And I am persuaded, if we would but reflect that there is a *Downward* to other Bodies in Nature, as well as to our Earth; that alone would reconcile us to their being habitable Globes: But wherever a Body revolves

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about another as a Center, that ſhews a *Downward.* The Moon rolls about our Earth; from *thence* therefore to us is downward: The Moons of *Jupiter* and *Saturn* roll about thoſe Planets; whence there is a Tendency down to theſe alſo.

*P.* And that a much ſtronger Tendency than to this Globe.——In fine, *Matho* (for we muſt have done) it is of Importance to conſider here, that the Deity might, according to his Good-Pleaſure, have created more or fewer Worlds: But to have applied them when created to no Purpoſe, or to have repleniſhed one little Globe with rational Inhabitants, and left innumerable others empty and uſeleſs, is the perfect reverſe of Art and Contrivance.

*M.* That could only have been the Effect of Power undirected by Wiſdom.

*P.* And then upon Reflection you will find one Thing extremely remarkable. The Mind of Man itſelf only reſts ſatisfied with thoſe Effects of Almighty Power, the Greatneſs of which it can neither conceive nor ſearch out; and this whether we conſider the *Grandeur*, the *Number*, or the *Subtilty* of his Works. For as long as it can fathom ſomething farther, ſo long it conceives Omnipotence circumſcribed; And ſince this is a repugnant

pugnant Thought, it rests only satisfied when it can explore no Limits to Power and Contrivance. And in this singular View the Power of the Deity offers itself to be revered and adored by us! It was observed before, that we can see a little about *the Middle*; but could we reach to either of *the Extremes*, we should find ourselves disappointed. The Mind would sit down discontented, having nothing more to look for. As this is a Mark of Eternity (shall I call it?) in the Mind of Man; so what Richness of Power is it, that we can neither find out the Beginning, nor the End, nor the Extent, of the Works of God! Ninth Conference.

*M.* What a noble View then of the material Creation have we from thence!

*P.* A quite different one certainly from that, which represents the celestial Orbs inclosing our Earth, as the *Shell* does the Kernel.

*M.* Name not that Disgrace of Philosophy. Here the boundless celestial Spaces, from East to West, from the North to the declining South, are appointed for Life and Habitation; the *Seats* of Reason and (if I durst so say) Humanity. I descry Worlds without Worlds; Suns and Systems, till the Imagination is wearied.

*P.* And there *Nature* and *Creation* begin anew, till the Creature sinks in endeavouring

vouring to graſp the Works of the Creator.

*M.* This after all is a Work, this only a World worthy of the *Omnipotent Architect*, immenſely Good, immenſely Powerful!

CXXIX. *P.* But does not the Conſideration of theſe Things give you ſome Concern, *Matho*, leſt the Deity ſhould neglect you, having ſuch a Multiplicity of other more important Affairs to look after?

*M.* This, as I obſerved before, *Philon*, can give me no Concern; while I reflect and feel, that the conſtant Action of the Deity a thouſand Ways ſupports me. While I look or walk, while I ſpeak or think, my corporeal Frame is preſerved by innumerable concurring Actions of Coheſion, Gravity, Repulſe, in every Part of my Body: Nay while I ſleep or breathe, and have not my Thoughts at my own Command, the Deity powerfully ſupports me. But why ſhould the Multiplicity of Affairs perplex the Deity? That only belongs to a limited Power. Did we ſee from the ſtrongeſt Reaſons that his Power, Wiſdom, and Goodneſs are infinite, only to forget the Conſequences of that Concluſion, when we had Occaſion to refer to them?

*P.* It is ſurely as you ſay, *Matho*; every Pulſe of the Artery, every Draught of Air we

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we fetch, every Motion and Change of material Parts we feel in our Bodies, is a Pledge of the present Power and Kindness of the Creator; so that he is no less powerful and good to us, than if he were powerful and good to us alone, and to no other Beings. And then, as you observe farther, since it is the Property only of limited Power and Knowledge, to be perplexed and confused with the Multitude of Business, it would be foolish enough to fancy that the Deity might be overpowered in exerting his Power, or confused with the Extent of his own Knowledge.

*M.* Such Notions are inconsistent, and destroy themselves. And from thence we may with Pleasure infer, that we cannot consider the Multiplicity of the Works of the Deity, as the Effect of his infinite Power; but we must at the same Time be sensible of our own Security, how small a Part of them soever we may be.

*P.* So little inconsistent indeed are these two, that the Care for *the whole* consists in a minute and constant support of *all the Parts*.

*M.* But pray, *Philon*, inform me here, how our Bodies are constantly preserved from the crushing Weight of the incumbent Atmosphere, by the Particles of Air in all their Parts? This you mentioned in great Hurry just at our last parting.

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*P.* I will not recommend that Notion to you (though it is the only thing that gives me Satisfaction in this particular) and it was for that Reason I mentioned it in such Haste: However I shall tell you in few Words what seems right to me; and you may choose or reject it afterwards, as it shall appear reasonable to you on Reflection. No human Force or Industry can bring the Particles of Air into Contact; hence the Spring or repulsive Force of the least Particle must be of itself sufficient to bear off the Weight of the whole.

*M.* I conceive a Quantity of Air then, as consisting of a Number of small Atoms, which suddenly start from one another, if at any Time they have been squeezed into less Room.

*P.* You are right; when the Air is strongly compressed, the Effort it makes to restore itself is incredible. Heat encreases the repellent Force of the Air, and generates no small Quantity of it, as we may see by the Vapour and Steam forced out from all combustible Bodies while they burn: From burning Gunpowder especially great Quantities of Air are produced. From this Increase of the Spring of the Air by Heat, and the new Quantities of it produced, proceeds that fierce Explosion, which throws out the Bomb, or Cannonball with such Violence.

*M.* You

*M.* In this manner may *Ætna*, or *Vesuvius*, rage by the same Force.

*P.* And the Earth itself tremble too.—Now since Air may be generated from other Substances, by Heat, or by Fermentation, it seems perfectly needless to enquire solicitously how it can get into all the Parts of our Bodies by external Conveyance; or to place the whole Stress of the Question in the formal manner how that can be effected. It was constantly in all Parts of them, as being generated inwardly; and the Quantity of it, sufficient to balance the Weight of the external Atmosphere, can never be wanting. Nothing else could save us from being crushed, unless we should call in the Help of a constant Miracle. This itself, I allow, is a constant Miracle: But then it is in the Course of Nature, and according to the Methods which we reckon commonly mechanical.

*M.* I understand pretty well what you say; but something still sticks with me for want of farther Information. What is the Weight with which you reckon the Atmosphere constantly presses us?

*P.* Since it presses us on all Sides, the Weight must be as the Surface it acts against. One Man may support a Weight as ten Tun, and another fifteen, or even twenty. But if a Man

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Man were ſqueezed by half of this on one Side, it would preſs him to Death in a Moment.

*M.* Why could not the internal Air in all Parts of his Body balance this Weight?

*P.* Becauſe it would have nothing to act againſt on the other Side. The Weight of the internal Air may be but a few Grains: This could never balance a Weight of ten or fifteen Tuns. But as ſoon as the Atmoſphere acts on the other Side, the internal Air by its repulſive Power defends itſelf in the Middle, and keeps off the Preſſure on each Side; ſo that we feel the Preſſure no more than if there were none.

*M.* I begin now to have a Notion of it. I fancied that the Preſſure on the one Side might balance the Preſſure on the other; or that the external Air formed a ſort of *hollow Caſe*, as it were, round the Body, which ſupported, or kept off the Weight. But now I ſee the repellent Force of the Particles muſt puſh them to act on all Sides.

*P.* While we blow up *Soap-Bubbles*, which was mentioned before, into a ſpherical Figure, we are not to imagine that the external Air forms itſelf into a hollow Sphere, which ſuſpends the Weight of the Atmoſphere from acting on the Sides of the included Bubble; though a ſpherical Figure be allowed to be the moſt advantageous for ſuch a Purpoſe.

If

If it were so, consider what prodigious Force it would require to blow up the Bubble, and thereby to form this hollow Sphere, or suspend the Pressure of the Atmosphere on all Sides of it. This shews us that it is the internal, or included Air, which (by its Spring) performs this Effect. And if this be so in a spherical Figure, it must be more so in any other Figure less regular. Ninth Conference.

*M.* You have entirely satisfied me on this Head, *Philon*. When I reflect on the various Shapes of all Sorts of Animals, and their constant Change of Figure while they move, the external Air cannot constantly throw itself into *hollow Cases* to keep off the Pressure of the Atmosphere from their Bodies.——But what was it you said, when we parted, of People that dive under Water?

*P.* The Water must press them on all Sides, and that in Proportion to the Depth they dive to; nor can any thing defend them, in my Judgment, but the Spring of the Particles of Air in all Parts of their Bodies: For the Water being an unelastick Fluid, or having no repellent Force between its Particles, is less fit than the Air to form itself into such ambient Figures, as might defend their Bodies from the Pressure. If this were so, it must defend them on all Depths alike: But the

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the farther they go down, they feel the greater Pain in their Heads, Eyes, and Arms: according as the Spring of the internal Air is more over-powered.

*M.* Why do you ſay that no human Force could bring the Particles of Air into Contact?

*P.* In the greateſt Degree of Compreſſion Men can give the Air, Bodies move up and down in it without a Reſiſtance ſenſibly greater than ordinary. If the Particles of Air could be brought into Contact, it muſt probably be as denſe, and therefore as heavy as Water.

*M.* I remember indeed what you ſaid, of breathing a fluid as denſe as Water, when you firſt mentioned to me *a repulſive Force.*

*P.* Now I hope we have done.

*M.* We muſt rather return back to our Subject concerning the Planets; for

CXXX. There are ſtill two or three Particulars I ſhould be glad to have your Thoughts of; and eſpecially with regard to one I aſked about ſome Time ago; namely, Since a ſkilful Artiſt does nothing at Random, or without Deſign, pray what do you take to be the Cauſe of the great Difference we find in the Revolution of the Planets on their Axis? *Jupiter*, the largeſt of them, performs more than

two Revolutions on his Axis, before *Mars*, or our Earth, though much inferior to him in Bulk, performs one. Ninth Conference.

*P.* It is as true on the one Side, *Matho*, that the great *Architect of Nature* does nothing at Random, or without Design, as it is on the other, that we cannot discover the Reasons in every Particular, why he hath contrived Things so; and this we must readily own, if we consider the infinite Difference between his Knowledge and ours.

*M.* This is a satisfactory Reason enough why we cannot know every thing; or rather indeed, why we can know but few Things.

*P.* You see it is not an Excuse contrived for our Ignorance, but a Truth flowing from the Limitation of our Knowledge, when compared with the Divine Intellect: Neither is it a Refuge devised to skreen the Works of the Deity from Enquiry and Examination. The better qualified any Person is to enquire into, and judge of these Works, so much the more Art and Skill will he find displayed in them.

*M.* All this is a plain Consequence of what has been so often said before.

*P.* To be satisfied therefore that the Divine Art reaches beyond our Faculties, is a negative sort of Knowledge, as necessary to be

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be kept in Mind, as any Thing we know moſt perfectly: And hence, if we would enquire ſoberly into the Works of Nature, we ought humbly to adore, and reverence a Knowledge ſuperior to our own, even in thoſe things, where we can neither comprehend the *End*, nor the *Means* conducing to it; for this alſo belongs to ſound Philoſophy. Otherwiſe, if once we ſhould imagine we were capable of knowing every thing, we muſt neceſſarily fall into the Abſurdity of ſuppoſing there can be no Reaſon for ordering things ſo, becauſe we do not ſee the Reaſon.

*M.* That would indeed be direct Folly and Madneſs.

*P.* Much leſs ought we ſo rigidly to inſiſt on a Reaſon for every thing, as to leave nothing to the Determination of the Good-Pleaſure and Will of the Deity; in ſuch Caſes namely, where the *End* admits of a diverſity of *Means* equally conducive to it in Nature. For ſome Philoſophers have idly contended, That the Frame of Nature could not ſubſiſt, if the diurnal Revolution of the Earth, for Inſtance, were but a Minute, or half a Minute, longer or ſhorter than it is. They demand a ſufficient Reaſon for every *Hair's Breadth*; otherwiſe the Hands of the Creator muſt be bound up: As if his Good-pleaſure were

were not really the most sufficient Reason in such Cases.

*M.* This is manifestly absurd, and contrary to common Sense at first Sight. Those affectedly nice Folks, under pretence of demanding a Reason for Things in themselves indifferent, seem rather determined, I think, to bring the Deity under Restraints at their Pleasure, contrary to Reason. But in the present Question concerning the different Length of the Revolutions of the several Planets on their Axes, that is, concerning the different Length of the Days in each of them, may we not suppose that the Convenience and Pleasure of their several Inhabitants is studied? For in the Planets, which are at the greatest Distance from the Sun, the Comfort of the Inhabitants seems to require that the Darkness should be shorter, and the Returns of Light more frequent, than in those which are nearer the Center of the System. Thus *Mars* and our Earth, whose diurnal Revolutions are nearly equal, seem to have but the same Distance, if compared with *Saturn* or *Jupiter*.

*P.* We may safely say in general, *Matho*, that the Convenience and Comfort of the Inhabitants is the End of all those studied Contrivances which are observable throughout the whole System: But it would be rash to be

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too particular in the Application of this general Concluſion; becauſe we may be too liable to fall into the Miſtake of meaſuring Conveniencies according to our own Conſtitution on this Globe: Whereas the Nature and Condition of the ſeveral Inhabitants, is probably as different as the Globe they reſide upon. We have Inſtances enough of this Diverſity of animal Life on our own Planet, to ſatisfy us that ſuch a Notion is not without Foundation. The *Ruſſian* Bear could as little live on the ſcorched Plains of *Africa* as the Lion or Tiger among the *Lapland* Snows. Some Creatures we obſerved ſleep for whole Months together: The quick Returns of Light and Darkneſs do not ſo much affect thoſe, as the ſlower Viciſſitudes of Summer and Winter. Some Creatures fly abroad only in the Dark, or charm us with their Muſick then, while others are repoſed in Silence at the ſame Seaſon.

*M.* This indeed I ſaw before: And among Vegetables likewiſe, ſome are fitted to thrive beſt in a cold Clime, whilſt others require a warmer Region; ſome are of a ſhort Duration, ſome preſerve their Verdure all the Year round; ſome appear early in the Spring, others later, through all Seaſons of the Year. There is, I perceive, an inexpreſſible Variety of

of Constitution both in the vegetable and animal Nature; so that I am obliged to you for reminding me of these Particulars on this Occasion. We are apt to require those Circumstances every where, which seem most convenient to our own Condition: Though it must be as absurd to imagine that all Things must be alike in the several Planets, as in all the Climes of the same Planet.

*P.* Agreeably to this therefore we see there is a great Diversity in their Revolutions on their Axes: *Mars* and our Earth perform their diurnal Rotation, as you observed, nearly in the same Time; but *Venus* and our Moon take a much longer Space; the Day in *Venus* being 23 of our Days, and in the Moon a whole synodical Month; while *Jupiter*'s Revolution is performed in less than ten Hours, and *Saturn*'s probably is not of much longer Duration. Hence, besides the Convenience you mentioned of the more frequent Returns of Light, another Advantage must accrue to the Inhabitants of those larger Planets, by their swift Rotation on their Axes.

*M.* What other Advantage?

CXXXI. *P.* The Gravity of Bodies on the Surface of *Jupiter* is twice as great nearly as on the Surface of our Earth. Wherefore

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if we reſided on that Planet, we ſhould be a Burthen to ourſelves, being preſſed down with double the preſent Weight, and having but once the Strength to ſupport it. But *Jupiter* is more than ten Times larger in Circumference than the Earth: Hence if both Planets revolved on their Axes in the ſame Time, the centrifugal Force in *Jupiter* would be more than ten Times greater than with us. But the Squares of their periodical Times are nearly as 6 and 1; or the Squares of the Number of Revolutions performed in the ſame Time by the Earth and *Jupiter* are as 1 and 6. Wherefore a Body placed on *Jupiter* will have 60 Times a greater centrifugal Force than with us: Which muſt be a notable Relief to the Inhabitants of that Planet, although perhaps endued with a greater Degree of Strength than we are.

*M.* This is an Advantage I did not attend to. And what Part of their whole Weight may it be, of which they are thus eaſed by the centrifugal Force of their Planet?

*P.* They are lighter by about a ninth Part of their whole Weight: Or a Body weighing nine Stone at *Jupiter*'s Equator, if the Planet ſtood ſtill, would gravitate with a Force but as eight Stone, upon the Commencement of its diurnal Rotation.

*M.* That

*M.* That must in Truth be a great Relief. But as *Jupiter* is ten Times larger in Circumference than the Earth, why is not the Attraction, or Weight of Bodies, ten Times greater likewise on his Surface than on our Globe?

*P.* If the Matter in him were as dense as in our Earth, the Weight of Bodies on their Surfaces would be as their Semi-diameters, or the Distances from their Centers: But the Matter in *Jupiter* seems to be made less dense with Design. For we can hardly imagine that Men of our Stature, for Instance, could support ten Times the Weight of such Bodies as ours are, with Ease; or have the free Command of Limbs so chained down by their own Gravity. And if we suppose them of a larger Stature, the Inconvenience becomes greater, the least of any Species being always observed to have the greatest Ease and Agility in Motion. And upon the same Account, though *Saturn* be 8 Times larger in Circumference than our Earth, equal Bodies are not 8 Times heavier on his Surface than on the Surface of this Globe; but in the Proportion of 17 to 10; that is, not much above once and a half as heavy.

*M.* I am almost fully persuaded that this is a wise Contrivance of the Creator; for the

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Eaſe of the Inhabitants and Animals reſiding on thoſe Planets.——But is it certain that Bodies gravitate but twice as much only on the Surface of *Jupiter*, as on our Earth? For this I look upon to be a Point of Importance.

*P.* It is certain they do not gravitate quite twice as much there as here; but in ſuch Caſes I chooſe to give you the neareſt whole Number to expreſs the Proportion; becauſe where nothing depends on it it is needleſs to trouble you with fractional Expreſſions, or the decimal Part of an Unit.

*M.* If it be practicable, pray make me underſtand this.

*P.* We are both of us already fatigued.

*M.* I ſhall leave you immediately after.

*P.* The Reaſon of the Thing is eaſily ſhewn: But a Calculation would be tedious.

*M.* The Reaſon of the Thing, with an eaſy Example to illuſtrate it, is all I deſire of you——

*P.* Firſt then, Bodies attract at equal Diſtances according to their Quantities of Matter; a Body having double or triple the Quantity of Matter attracts twice or thrice as ſtrongly at the ſame Diſtance, as a Body having but a half or a third Part the Matter.

*M.* This

*M.* This is plain enough.

*P.* If therefore two Satellites revolved about *Jupiter* and our Earth, at equal Distances from their Centers: the Forces with which they were attracted would be as the Quantities of Matter in *Jupiter* and the Earth respectively.

*M.* That is but the same Thing in other Words.

*P.* Their centrifugal Forces likewise (which you know are always equal to the centripetal) should be as the Quantities of Matter in the two central Bodies.

*M.* That comes still to the same Thing.

*P.* The Squares of the Number of Revolutions, performed by these Satellites in the same Time, should also be as their centrifugal Forces.

*M.* This you shewed me to Satisfaction before. And the Squares of the periodical Times are inversely as the Squares of the Number of Revolutions performed in the same Time: For in the Example of our two Moons, the periodical Time of the outer Moon was 8 Times longer than the periodical Time of the *inner*; therefore the Number of the Revolutions of the inner Moon was 8 Times greater, so that 64 was the Square both of the one and the other.

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*P.* From this then it follows, that the Quantity of Matter in *Jupiter* will be to the Quantity of Matter in the Earth, as the Square of the periodical Time of the Earth's Moon is to the Square of the periodical Time of *Jupiter*'s Moon revolving at the ſame Diſtance from him.

*M.* I perceive all the Steps in this Argument very diſtinctly;——but none of *Jupiter*'s Moons perhaps revolve at the ſame Diſtance from his Center, as our Moon does from the Center of the Earth.

*P.* Our Moon you know is 60 Semi-diameters of the Earth from its Center: Now you may eaſily find out in what Time a Satellite would revolve about *Jupiter* at the ſame Diſtance from his Center; ſince the Cubes of the Diſtances are as the Squares of the periodical Times.

*M.* I muſt ſuppoſe then that a Satellite revolves about *Jupiter* at that Diſtance; and find the Time of its Revolution by this Proportion?

*P.* You muſt; and it is eaſily done: For taking *Jupiter*'s innermoſt Satellite, *v. gr.* whoſe Diſtance from his Center is about 55 Semi-diameters of our Earth, and its periodical Time 42 Hours 28 Minutes, or 2548 Minutes; ſay, as the Cube of the Diſtance

55

55 is to the Cube of the Distance 60, so is the Square of 2548 Minutes to a fourth Number, which will be the Square of the periodical Time of a Satellite revolving at 60 Semi-diameters of our Earth from the Center of *Jupiter*. This Number you will find to be about 8428776. The periodical Time of our Moon is 27 Days, 7 Hours, 43 Minutes, or 39343 Minutes, whose Square is 1547871649. Thus the Matter in *Jupiter* will be to the Matter in the Earth as 1547871649 to 8428776; or as 184 to 1. Ninth Conference.

*M.* This I shall try as accurately as I am able;——But what is all this to Bodies gravitating only twice as much on the Surface of *Jupiter* as on our Earth?

*P.* If *Jupiter* were as dense as this Earth, he must have a 1000 Times more Matter than is in the Earth, because Globes equally dense are as the Cubes of their Diameters; 10 and 1, to wit, in this Case. And since the Attraction increases as the Cubes of the Diameters, or Matter; but decreases as the Squares of the Diameters, or Distances; his Attraction on his Surface should be as a 1000 divided by a 100; or as 10 and the Earth's as 1. But his Matter is only 184: Therefore the Attraction on his Surface is only as 184 divided by a 100; and the Earth's as 1. That

is,

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is, the Attraction on his Surface is not twice the Attraction on our Globe.

*M.* It could not be twice as great, unleſs the Matter in him were 200 Times as much as in the Earth; for then 200 divided by the Square of the Diameter [100] would only be 2, while the Earth's was as 1.

*P.* You are very right.

*M.* And what is his Denſity with Reſpect to the Earth's?

*P.* Although his Matter were 200 Times as much as that in the Earth, he takes up a 1000 Times the Space, with only 200 Times the Matter. Divide the Matter 200 by the Space a 1000; and you ſee even then he would be 5 Times rarer than the Earth; or have but a fifth Part of its Denſity.

*M.* Well, I am extremely pleaſed with all this; and am now fully perſuaded that this Rareneſs of Contexture in thoſe larger Planets was wiſely deſigned for the Sake of Inhabitants reſiding upon them, who otherwiſe muſt have been oppreſſed by their own Weight.—In what Time would this other Satellite revolve about *Jupiter*, at the Diſtance of 60 Semi-diameters of the Earth from his Center?

*P.* The Matter in *Jupiter* is the Square of the Number of Revolutions it would perform, while our Moon revolves once about the

the Earth: And the Square Root of 184 is 13, 5. It must therefore revolve 13 Times and a half about *Jupiter* in the Time of our periodical Month. Or the Square Root of the other Number 8428776, *viz.* 2903, 2 is the periodical Time of this Satellite in Minutes; which comes to 48 Hours 23 Minutes.

*M.* I think I now understand enough to initiate me into these Calculations. Wherefore I shall not give you any farther Trouble at present.

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*As the Weight of Bodies on the leſſer Planets is but ſmall, their Rotation on their Axes is ſlow, and their centrifugal Force but weak. Heat and Light are diſpenſed rather according to the Surface than the Quantity of Matter in the luminous Body; hence the Sun is but of a moderate Denſity. That the outermoſt and innermoſt of the Planets are not uninhabitable by Reaſon of the Extremities of Heat or Cold. Heat is not always in Proportion to our Vicinity to the Sun: Cold requires a poſitive Cauſe, or ſomething more than the mere Abſence of Heat. The Extremities of both may be qualified by the Conſtitution of an Atmoſphere. That all the Planets are ſurrounded with Atmoſpheres. The phyſical Explication how Bodies may deſcribe elliptical Orbits about an attracting Body, placed either in the Center of the Ellipſis, or in one of its Foci; according as the Law of Attraction is ſuppoſed different. Theſe two Caſes compared between themſelves, and the Tranſitions from*

*the one to the other shewn natural and easy. The Proportion between the Squares of the periodical Times and Cubes of the middle Distances, still observed when Bodies revolve in Ellipses. The Comets revolve by the same Laws, and observe the same Proportions as the Planets.——Of the Immortality of the Soul. That the Soul is not assisted to think and perceive by Organs of a dead Substance; but is by these confined and limited to a particular Manner of Action and Perception. Whether the Deity could cut off rational Beings, for whose sake the material World was created; the Frame itself still remaining. The Desire of Existence the Foundation of all our other Desires, and the Source of all great and virtuous Actions. A happy Existence the only Object of Desire in the Nature of Things. Utter Extinction no Object of Desire. The Disingenuity of the Atheist. The Mistake of those who separate Virtue from a Love to ourselves. Atheists could not live together in Society on their own Principles. The false reasoning in Mr.* Bayle's *Apology for the Atheists. The Atheists Account of the Rise of Religion. The Wonders in the material Creation designed to instruct Beings appointed for Immortality. The material Creation*

*Creation the inferior, and leaſt wonderful Part of the Works of God.*

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CXXXII. *M.* YOU ſee me here once more, *Philon*; and to begin where we left off——

*P.* You begin abruptly enough, I think, *Matho.*

*M.* There is no need of reſuming what was ſaid laſt. I underſtand it tolerably well; nor would I deceive my ſelf in a thing of this Nature.——I am much in Love with what you told me concerning the Quantity of Matter, and Denſity of the Planets, as alſo concerning their centrifugal Force, while they turn round on their Axes. But what is the Reaſon that we cannot find out the Quantity of Matter in *Mars* or *Venus*, as we do in *Saturn* or *Jupiter?* This, I remember, you ſaid was not known.

*P.* The Reaſon is, becauſe they have no Satellite (none conſpicuous to us I mean) revolving about them. Had they Satellites revolving about them, whoſe Diſtances and periodical Times were known, we could diſcover in what Time a Satellite ſhould revolve about either of them, at any aſſigned Diſtance; and thereby compare their Quantities of Matter, and Denſities with thoſe of any other Body in the Syſtem. *M.* Of

*M.* Of any other primary Planet, you mean, which hath a Satellite revolving about it?

*P.* That I ought to have said.

*M.* Then we cannot know the Weight of Bodies on their Surfaces; nor compare *that* with their centrifugal Forces?

*P.* We cannot; though the centrifugal Force on *Mars* must be considerably less than on our Earth, both because his Rotation on his Axis is somewhat slower, and his Diameter is much shorter; and on *Venus* the centrifugal Force is quite inconsiderable: But then, as these are only small Planets, the Weight of Bodies upon them cannot be very great. In *Venus* it may be nearly the same as on this Globe; and were we on *Mars*, we could not feel much above half our present Weight.

*M.* It was reasonable that the centrifugal Force should be small, where the Weight was otherwise tolerable: For I now see that, the more swiftly any Planet revolves on its Axis, the more the Weight of Bodies upon it must be diminished.

*P.* Undoubtedly: For these two Forces act contrary to each other in this Case, as much as in the Revolution of Planets round the Sun; since the centrifugal Force of Bodies proceeds from the Inertia of Matter, by

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which they always tend to move on in the ſame Direction.

*M.* But in the Revolution of Planets round the Sun theſe two Forces were in Equilibrio.

*P.* The Reaſon of that, you remember, is, leſt the Planets ſhould be drawn down to the Sun, or run out to a greater Diſtance from him; as the one or the other of theſe Forces prevailed: Whereas, had they been in Equilibrio here, Bodies would not at all have gravitated to their proper Center. Not only our Bodies would not firmly have participated of the Earth's diurnal Rotation, but our Houſes muſt have been looſe and tottering, or in conſtant Suſpenſe betwixt ſtanding and falling (for it is not eaſy to imagine the Caſe exactly); nor could the Ground itſelf have been a firm Support and Foundation for any thing.

*M.* I perceive ſomething here which I cannot well expreſs.

*P.* Nor can I underſtand it, unleſs you expreſs it in ſome Way or other.

*M.* It was as neceſſary that the centripetal Force ſhould prevail over the centrifugal, with reſpect to the diurnal Rotation; and that in a different Degree, according to the different Weight of Bodies on the larger and leſſer Planets; as that *theſe Forces* ſhould balance each other with reſpect to the annual Revolution:

And

And in both Cases we see them wisely adjusted in great Variety of Circumstances. In short, it is new Matter of Admiration, to see the centrifugal Force weak, where the Gravitation is small, and strong, where the Weight of Bodies becomes greater.

*P.* The Observation is just; and the Expression at least intelligible.——

*M.* But in what Time must our Earth have turned round on its Axis; so as to have made these two Forces equal?

*P.* The centrifugal Force at the Equator (where it is greatest) is to the centripetal as 1 to 289. The Square-Root of this Number 289 is 17.

*M.* Pray let me go on with the rest of the Argument by myself.——Since the centrifugal Force is encreased with the Square of the Number of Revolutions performed in the same Time; if the Earth performed 17 Revolutions in the Time it performs one, the centrifugal Force at the Equator would have been 289 times greater than it is at present, and therefore equal to the Weight of Bodies there, which consequently must have been in constant Suspense between flying off from the Earth, and remaining on its Surface: So that a small Force must have given them a

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Motion to any Side, just as if they had been quite without Gravity.

*P.* You deduce the Argument very accurately.

*M.* But pray what would be the Consequence, if the Earth rolled round a little more swiftly than at the rate of 17 Revolutions in 24 Hours?

*P.* From what you have said just now it follows, that all Bodies at the Equator would then be thrown off from the Surface Eastward: But by the Action of Gravity retracting them, they would fall back again to the Earth. And thus they would constantly be cast off and fall back without ceasing; nor could any thing be firmly settled in one Place, but as it lay nearer the Poles, where the Rotation was less violent.

*M.* This would be a wild Confusion for a habitable Globe!——But let me recollect a little.——

CXXXIII. Seventeen Revolutions in twenty-four Hours is, I think, one Revolution in less than an Hour and a half.

*P.* It is one Revolution in an Hour and about 25 Minutes.

*M.* Then, as it appears to me, you argued inconsistently before, when we were speaking of

of the diurnal Rotation of the Earth, where you supposed that it might turn round on its Axis every quarter of an Hour; since in that Case every thing must be thrown off from its Surface with inconceivable Rapidity: Or rather the whole Mass would be shaken quite asunder, except perhaps a small Quantity about the Axis of its Motion. Tenth Conference.

*P.* You urge the Consequence very well; the whole Mass would then be shaken quite loose: Notwithstanding I have a right to make that Supposition, because you know it is equally possible, that the Gravity of Bodies should be augmented, as that the diurnal Rotation of the Earth might be accelerated, and that to any Degree; for it belongs equally to the same Power to effect a Change in either. The Supposition was therefore consistent enough, and proper to the Subject we were then discoursing upon. For in that Case you could less have perceived the Motion of the Earth by the Help of your Senses, than at present; since the Heavens and heavenly Bodies must have appeared to roll over our Heads west-ward, with greater Velocity than a Bird flies.

*M.* I understand: *That Supposition is consistent, which does not imply a natural Impossibility.* And your Argument was as if you

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had ſaid, " Had it pleaſed the Almighty Cre-
" ator, ſo to encreaſe the Gravity of Bodies,
" and accelerate the Earth's diurnal Rotati-
" on, that it ſhould have rolled round on its
" Axis in ſuch a Time."——After this pleaſe to ſhew me in what Time *Jupiter* muſt have rolled round on his Axis, ſo that the centrifugal Force of Bodies on his Surface might have been equal to their Weight or Gravity?

*P.* This you ought now to find out for yourſelf, ſince you have the Diſtance and periodical Time of his innermoſt Satellite.

*M.* It is true; for I have already half of my Work done in the laſt Example. Then, ſince Bodies on *Jupiter*'s Surface are 10 Semi-diameters of our Earth diſtant from his Center; it will be, as the Cube of 55 to the Cube of 10; ſo the Square of 42 Hours 28 Minutes, or of 2548 Minutes, to a fourth Number, which muſt be the Square of *Jupiter*'s periodical Time on his Axis, that Bodies on his Surface might have their Gravity and centrifugal Force equal. Or it will be as 166375 to 1000, ſo 6492304 to a fourth Number.

*P.* Which fourth Number you will find to be 39022; and the Square-Root of 39022 is 197, 5 Minutes; or 3 Hours 17 Minutes.

*M.* What

*M.* What is the exact Time of *Jupiter*'s Revolution on his Axis at present?

*P.* Nine Hours 56 Minutes.

*M.* *Jupiter* then performs but three Revolutions for one, that Bodies on his Surface may have their centrifugal and centripetal Forces equal; whereas our Earth should perform 17 Revolutions for one.

*P.* The Reason of which is, because a great Part of the Gravity of Bodies on the Surface of *Jupiter* is taken off, by his swift Rotation at present.

*M.* Right. I see now that a ninth Part of their whole Gravity is taken off by their present centrifugal Force, as you told me before; or the centrifugal Force is but 9 times greater, when the whole Gravity is taken off; since it is as the Squares of the Number of Revolutions performed in the same Time, 3 and 1.

*P.* You have it exactly.

*M.* From this then I now also understand more clearly, what we have once or twice touched upon before; namely, why the Earth is higher about the Equator, and more flat and sunk about the polar Regions; which Inequality ought, I think, to be more remarkable in *Jupiter*.

*P.* What are your Thoughts of that Particular now?

 *M.* From

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*M.* From the greater centrifugal Force about the equatorial Parts, the Matter there is relatively lighter; and is therefore more raiſed to make an Equilibrium.

*P.* The Inference is juſt; and on our Earth the Matter of Fact is confirmed both by meaſuring and other Experiments: But on *Jupiter*, whoſe diurnal Rotation is ſwifter, and the centrifugal Force therefore greater, the Inequality, as you obſerve, is ſtill more plain. For whereas in the Earth the equatorial Diameter exceeds the polar, but by one 230th Part of itſelf, or they are as 230 to 229; in *Jupiter* they are to each other as 11 to 10 nearly.

*M.* That is a notable Difference, and agrees well to his centrifugal Force.

*P.* The Difference is almoſt as great as the whole Diameter of the Earth, which is but about a 10th Part of *Jupiter*'s.

*M.* Here again, I think, ſomething is naturally ſuggeſted to us.

*P.* What?

*M.* That the Planets were firſt formed, and made ſpherical by the mutual Attraction of their Parts, before they received their diurnal Rotation: For this Riſing, or Swelling, about the Equator ſeems naturally to have been induced on a former ſpherical Figure.

*P.* It

*P.* It must indeed appear so to us in the Order of Nature.

*M.* Since then we must conceive the Planets as first without their diurnal Motion, we may with Pleasure see, as it were, this Rotation impressed on those prodigious Globes, by the Almighty Hand of the Creator.

*P.* I agree with you. One, who considers Things in this philosophical View, will feel all the Pleasure you mention, in thus tracing the Original of the diurnal Rotation. And it appears somewhat inartificial first to suppose that the Deity moulded the Planets into this oblate spheroidical Figure (as it is called;) and that then he impressed a Motion upon them which must of itself naturally have produced that Figure. For, as you well observed in our fourth Conference, the Attraction of Gravitation leaves Matter still in the most fluid Form possible: So that a Body once brought into a spherical Figure, by this Affection between all its Particles, must necessarily, by a Rotation on an Axis, be elevated about the Equator of its Motion, and thereby become an oblate Spheroid.

CXXXIV. *M.* Pray what may the Weight of Bodies be on the Surface of our Moon?

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*P.* If the Earth and Moon were of the ſame Denſity, Bodies there could have little more than a fourth Part the Weight they have here, according to the Diameters of the two Planets. But becauſe of the greater Denſity of the Moon, the Gravity of Bodies on the Earth is to the Gravity on her Surface as 293 to 100: That is, were we there we could not feel much above the third Part of our preſent Weight.

*M.* Much centrifugal Force on that Planet then muſt have been, I think, inconvenient, as rendering Bodies too light.—After this it would be needleſs to aſk what the Weight of Bodies might be on the Surface of the Sun, ſince he cannot be ſuppoſed habitable; and the Gravitation of Bodies muſt be exceſſively great, ſo near the Center of Attraction of the whole Syſtem.

*P.* It is not ſo great as you may imagine, *Matho:* Heat and Light are diſpenſed rather according to the Surface than the Denſity of the Body, or the Quantity of Matter in it. Hence the Sun is not one of the denſeſt Bodies of the Syſtem. And the Gravity on his Surface is reckoned but about 24 Times more than that on the Surface of the Earth.

*M.* I ſee it is reaſonable that the Light ſhed round, and perhaps the Heat too, ſhould rather

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rather be as the Surface of the luminous Body, than as its Denſity; but I had quite other Notions of the Attraction or Gravity ſo near the central Body: Make me underſtand therefore, if you pleaſe, how this ſhould be?

*P.* The Quantity of Matter and Denſity in the Sun is diſcovered the ſame Way as the Quantity of Matter and Denſity in *Jupiter*; namely, by computing in what Time our Moon would revolve about the Earth, at the ſame Diſtance from it as *Venus* is from the Sun.— As to the Denſity of Bodies, and Gravity on their Surfaces, you may perphaps get an eaſy general Notion of theſe, by conſidering the two following Caſes as *Extremes*. If the Matter in the Sun and Planets were as the Cubes of their Diameters, they muſt all have the ſame Denſity, and the Weight of Bodies on their Surfaces muſt be directly as their Diameters: For the Attraction increaſing as the Matter or Cubes of the Diameters, and decreaſing as the Squares of their Diameters, the Cube divided by the Square would always give the Diameter to repreſent the Attraction of the Surface.

*M.* This was obſerved before.

*P.* But if the Matter were only as the Squares of the Diameters, the Denſity would be inverſly as the Diameters; and the Weight of

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of Bodies would be the ſame on the Surface of all Planets, let their Quantities of Matter be ever ſo unequal.

*M.* I underſtand nothing at all of this.

*P.* Suppoſe there are two Planets whoſe Diameters are 1 and 10; and if, in Order to find out their Denſities, you divide the Matter (which is as the Square of the Diameter) by the Space it takes up (which is as the Cube of the Diameter), it will be 1 divided by 1, for the firſt Planet; and a 100 divided by a 1000, for the ſecond: Or their Denſities will be 1, and one tenth.

*M.* Thus far I ſee: The ſecond will have but one tenth the Denſity of the firſt, as its Diameter is ten Times larger. Thus if the Matter in *Jupiter* were but a 100 Times the Matter in the Earth, he ſhould have but a 10th Part of its Denſity, or be 10 Times more rare.

*P.* And the Weight of Bodies on the Surfaces of all the Planets would then ſtill be the ſame: For the Attraction increaſing as the Matter, or Square of the Diameter, and decreaſing alſo as the Square of the Diameter, the Square of the Diameter divided by the Square of the Diameter will always be equal to Unity, how different ſoever the Diameters may be among themſelves.

*M.* Now

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*M.* Now you have given me Satisfaction; for I understand the Consequence of both Suppositions, either when the Matter is as the Cubes, or as the Squares of the Diameters. And as any particular Instance, draws near to the one or the other of these Cases (which you call *Extremes)* the Gravity on the Surface of that Planet will be more or less accordingly.

*P.* Both Cases may be exemplified in one and the same Body, the Quantity of Matter in it remaining also the same; only by supposing its Diameter different.

*M.* Pray shew me how?

*P.* If the Diameter of the Sun be supposed a 100 Times the Diameter of the Earth, and the Quantity of Matter as the Cubes of their Diameters, their Densities will be equal, and the Weight of Bodies on their Surfaces directly as their Diameters: But if the Diameter of the Sun be supposed 1000 Times the Diameter of the Earth, the same Quantity of Matter remaining, their Densities will be inversely as their Diameters, and the Weight of Bodies the same on both their Surfaces.

*M.* I conceive it: Though the Matter in the Sun be still a Million of Times more than the Matter in the Earth; in the first Supposition

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sition it is as the Cube of the Diameter a 100, and in the second as the Square of the Diameter 1000: And the Surface of the Sun in the last Case being 10 Times farther from the Center, than in the first, the Attraction there will be 100 Times less, or equal to the Attraction on the Surface of the Earth. This is agreeable enough, and gives me a more familiar Notion of these Things.

CXXXV. *P.* You see then by what artful Methods, of more or less Density, and more or less centrifugal Force, it comes to pass, that the Weight of Bodies on the larger and lesser Planets, is not near so different as the different Quantities of Matter in the Planets would seem to import?

*M.* I see every Thing in the System consistent, if the Planets are considered with a View to *Habitation*; whereas without that, the Design seems broken and incoherent.

*P.* Especially if we suppose the Earth alone designed to be habitable; while the Rest are left solitary and unfrequented.—

*M.* Notwithstanding there seems to remain still one Inconvenience.

*P.* What is it?

*M.* That the Heat of the Sun cannot be multiplied at the Extremities of the System, by

by Reflection, as his Light is. The hundredth Part of our Heat must make *Saturn* but a comfortless Place. 

*P.* As we saw before, *Matho*, that the animal Constitution, with Respect to Heat and Cold, may be widely different on the same Planet; so there may not be such a Difference of the Degrees of Heat and Cold, on the Planets nearer to and more remote from the Sun, as we imagine. The Causes of Heat are more than one, as we may observe by what happens in the Bowels of the Earth, in *Fermentations*, in *Ebullitions*, even in our own Bodies; and especially by common Fire. *Cold* likewise seems to imply something more than a mere Privation of Heat, and to depend on some very active Principle. This will appear more probable, if we consider the violent and sudden Effects of Cold, in some common Experiments of artificial freezing; and when the Barrel of a Gun, or the Shell of a Bomb, though of considerable Thickness, is violently burst by the freezing of the Water contained in it; that shews quite another Sort of Principle, than the mere *Inertia*, or Sluggishness of the Particles of Matter. The Rays of the Sun are certainly productive of Heat; but (by the Accession, or Co-operation of some other Cause) not always in Pro-

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Proportion to their Denſity, or the Vicinity of the Body to the Sun: Otherwiſe we ſhould always have the ſame Degree of Heat or Cold, at the ſame Time of the Year, regularly in a Circle; which nevertheleſs you ſee we have not.

*M.* This is indeed common Experience, and ſeems to prove eaſily what you ſay. I have often obſerved very ſoft Weather, and mild Nights in the Depth of Winter, when a long Froſt has been ſucceeded by a quick Thaw; and contrarily, bitter Winds and a froſty Air, when the Sun has been near the Summer Solſtice.

*P.* This ſeems to proceed from the Conſtitution of our Atmoſphere, and the Alterations happening in it; which produce ſometimes ſultry Heat, and ſometimes piercing Cold, directly contrary to what ſhould be the Effect of the Sun's Rays ſeparately conſidered: So that *Heat* and *Cold* do not abſolutely depend on a Planet's Nearneſs to, or Diſtance from the Sun, but together with theſe, on ſome other Cauſes. We are conſiderably farther from the Sun in the Summer Months, than in the Winter, and for all that our Weather then is generally much warmer.—Now, though *Saturn* has but about the hundredth Part of the Sun's Heat which we feel, I am not

not sure if the hundredth Part of our Heat will amount to any Degree of positive and real Cold, without the Co-efficency of some other positive and real Cause. And it is not difficult, I think, to conceive, that the Constitution of his Atmosphere may be such, as to make that Planet a mild and temperate Clime. And if there be any Weight in this reasoning, it will not be hard to apply it to the inferior Planets, *Mercury* and *Venus*; for we sometimes feel the Heat of our Summer as much qualified by some different Cause, as the Rigor of our Winter.

*M.* There is indeed so much Reason in all this, that at least I shall not be so rash in drawing Inferences from narrow Principles in this Affair, as otherwise I should have been. One Thing notwithstanding surprizes me; *viz.* why the Earth should be farther from the Sun at one Time than another: But before I ask you concerning this Particular, I beg you would tell me, why you suppose there is such an Atmosphere about each of the Planets, as about our Earth?

*P.* I must suppose there is an Atmosphere about every one of the Planets, unless I would imagine them to be Globes of Adamant, or something still more hard. Every Thing about our Earth is in constant Change: I am

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not certain if we can except any Species of Bodies that can be named. Metals themſelves ſeem gradually to decay, as well as come to a State of Maturity. Every Thing therefore contributes its Share to the Atmoſphere, which is an heterogeneous Mixture of all Sorts of Particles. Thus, unleſs we would ſuppoſe that the Matter in the Planets is not acted upon in the ſame Manner as the Matter in our Earth; which would be a Suppoſition without Foundation, and contrary to Reaſon; we muſt conceive that they have Atmoſpheres about them, like to that which is about the Earth. A Degree of Repulſe (leſs or more) is the Principle of Diſſolution of all natural Bodies, if we may ſpeak mechanically on this Head, and without conſidering the immaterial Cauſe of this Repulſe: And repellent Particles are moſt fit to join themſelves with the Atmoſphere, and to become a Part of it. It is this Principle which occaſions what is called *Effluvia* from particular Bodies: And the Effluvia of the Planets (if I might be allowed ſo to ſpeak) conſtitute their Atmoſphere.

*M.* I am afraid you are going too deep with me, though hitherto, I think, I underſtand what you ſay with Pleaſure: But what I meant by my Queſtion was, Whether the Atmoſpheres of the Planets can be diſcerned by Obſervation? *P.* It

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*P.* It is not necessary to the Constitution of an Atmosphere that it should have visible Clouds, and thick palpable Fogs: Our Atmosphere exists no less when the Air is serene and clear, than when it is heavy and clouded. It is observed that the highest of the Clouds, when their Height is measured, are not found to reach above a Mile from the Surface of the Earth: But allowing them to be two or three Miles high; what is that to the Distance of the Planets? To suppose that Observation might determine here, is to suppose the Object within the due Distance; which is the Mistake in several other Cases. Our Atmosphere, how high soever, transmits the Light of the fixed Stars to us, as you observed before: And if we may reason from Analogy, the Atmosphere of other Planets should do the same. Besides, as far as Observation can reach, both our Moon and *Mars* are discovered to have Atmospheres: In the Appulses of *Mars* to the fixed Stars, they are observed to become obscure and dim; and in total Eclipses of the Sun, the Moon's Atmosphere becomes perceptible.

*M.* It seems indeed, wherever there is Heat and Moisture there must be Vapours; and consequently an Atmosphere.

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*P.* Nay, wherever there is Cold there muſt be an Atmoſphere; for Vapours are obſerved to riſe plentifully in the hardeſt Froſt.

CXXXVI. *M.* Pray tell me now, if it be true that we are nearer the Sun in the Winter than in the Summer; how comes it to paſs that we feel ſo much more Cold when nearer him, than when farther diſtant from him?

*P.* You ſhould have propoſed this Difficulty, *Matho*, long ago; for when you ſuppoſed that our Diſtance from the Sun was always the ſame, you ſhould either have aſked this Queſtion then, or inferred, becauſe we were equally near the Sun, Summer and Winter, that we muſt have had the ſame Degree of Cold all the Year round.

*M.* I'm afraid my Queſtion is not ſo much to the Purpoſe as I imagined.

*P.* It is obvious that the Rays falling more or leſs obliquely on the Surface of the Earth muſt occaſion a great Difference in the Degrees of Heat. Hence it muſt be leſs when the Sun ariſes but a little above our Horizon in the Winter, than when he mounts higher, and darts his Rays more perpendicularly upon us. You find when you hold any Thing directly oppoſite to the Fire, it is more ſtrongly heated, than when you turn it ſide-ways at the ſame Diſtance.

*M.* I

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*M.* I perceive it must be so: But in what Proportion will this oblique Incidence of the Sun's Rays increase or diminish the Heat, the Distance being the same?

*P.* I am not sure if the Proportion which seems just to me will appear so to another.

*M.* Tell it me however: A Guess sometimes helps us to come nearer the Truth afterwards.

*P.* 'Till you can come at something more authentic then, you may suppose that the Density of the Rays, and therefore the Degree of Heat, will be as that Line which is called the *versed Sine* of their Inclination, or Angle of Incidence.

*M.* Shew me this by a Figure?

*P.* You may see it from any Circle. In this Figure, if the Sun be perpendicular over the Plane, the Rays will be the densest possible at that Distance; and their Density may be expressed by the Radius. But if the Sun be in this Position (suppose 32 Degrees from the Vertex) drawing a Line from him to the Center, none of the Rays on the upper Side of the Line, you see, will fall upon the Radius, and those only on the under Side are now spread over it all. But these are only the Rays which fell upon *this Part* of it, when the Sun was vertical; which Part is the vers-

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ed Sine of the Angle of Incidence of the Rays.

*M.* So it appears indeed from the Inſpection of this Figure: And at this Rate what may be the Proportion of our Heat in Winter to that in Summer?

*P.* If this Proportion be juſt, abſtracting from the Difference of Diſtance, and all other Cauſes of Heat, except the Denſity of the Rays, our Heat in Winter will be about the ſix and twentieth Part of what it is in Summer. For ſuppoſing our Latitude 55 Degrees and a half, the Sun's greateſt Altitude in Summer will be 58 Degrees, and in Winter only 11; the verſed Sines of theſe are 4849619 and 183728, which are nearly as 26 and 1.

*M.* All this I underſtand, and am ſatisfied that the ſix and twentieth Part of our Summer's Heat is no Degree of Cold: For it is ſtill Heat perceptible to Senſe. And how great may our Heat in Summer be, with Reſpect to the Heat at the Equator, when the Sun is vertical to them?

*P.* Our Heat muſt be about half of theirs; for the verſed Sine of 58 Degrees is ſomewhat leſs than half the Radius.

*M.* This Proportion will farther ſhew us the Denſity of the Sun's Rays at any Time of the Day, as well as any Time of the Year, according to his Altitude? *P.* If

*P.* If it be just in the one Case it must be so in the other.

*M.* I see no Objection against the Justness of it, at present; and even though it should not be precisely just, thus much seems certain, that another Cause mixes itself with the Effects of *Heat* and *Cold*, besides the greater or less Density of the Sun's Rays, or even his total Absence.——Now, as to the Earth's being at a greater Distance from the Sun, in Summer than in Winter; if this be so, I know not what to say. I thought a Body could not have revolved about the Sun in any other than a circular Orbit, without being drawn down to him, or running out through the celestial Spaces; and this Notion you seemed to approve of: This stumbles me exceedingly.

*P.* In all such Subjects, *Matho*, People generally begin, you know, with the easiest Cases: To tell them of more intricate and difficult Things at first would only tend to discourage them. And that is the simplest Case of one Body's revolving about another, by the Composition of an attractive and projectile Force, when it moves in a circular Orbit. As this Case is plain, you easily conceived it: Yet it is no less true that a Body may describe about another an *oblong* or *elliptical Orbit*.

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This is more difficult to be conceived, but it no Way invalidates the Truth of what you already know. The Orbits of the Planets are not exactly circular, yet they differ not much from real Circles, having but a small Degree of Eccentricity. This Method was intended, not to stumble you, but for your more easy Conception.

*M.* You satisfy me as to the Reasonableness of the Method, which I ought to leave entirely to you; if it were possible to observe a Method in such a loose Discourse, where so many Things offer accidentally. But can I be made to understand how a Body may describe an oblong or elliptical Orbit about another, without falling quite down to it, or running out through the ambient Space?

*P.* Not perfectly, I am afraid. It will require too many Words, and many childish Suppositions. Great Men understand this in their own superior Way, without accommodating themselves to our Conceptions.

*M.* An imperfect Notion is better than none at all. The more childish your Suppositions are, the more they will suit my Capacity: And as for Words, I told you, I often discourse for whole Hours together, without any other Advantage than having got rid of so much Time. And at worst, as we are by ourselves, there

there can be no Harm in making a Trial, though it should prove unsuccessful. Tenth Conference.

*P.* Well, on these Terms we may make a Trial: It will be but a little Labour lost.—

CXXXVII. But before we begin, it will be necessary to acquaint you with some general Things concerning the *Ellipsis*. Here is the Figure itself. It is described about two Points, as the Circle is about one. These Points (marked with the Letters F and f) are called its *Foci*. As these Points may still recede farther from, or draw nearer to the middle Point, or Center C, the Ellipsis may be more or less oblong, that is, more or less eccentrical, 'till it becomes a *straight Line* on the one Extreme, or coincides with a Circle on the other.

*M.* This is plain enough; for I have seen Carpenters draw such Figures on the Floor, about two Pins, with a double Cord and a Piece of Chalk, when they were going to make an *oval Table:* And we have sometimes diverted ourselves in drawing the like Figures, when the Workmen were gone.

*P.* Then your Diversion will prove a Means to facilitate the Matter to you now. These two Lines, which cross each other in the Center at right Angles, are the *greater* and

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*leſſer* Axis. If the Attraction be to the middle Point, or Center, when the Body, moving in the Perimeter of the Ellipſis, comes to the Extremity of the leſſer Axis here, it will be at the neareſt Diſtance to the central Body; and at either Extreme of the greater Axis, the fartheſt from it. But if the Attraction be to this *under Focus* F, when the revolving Body comes to the Extremity of the leſſer Axis, it is ſaid to be at the middle Diſtance from the attracting Body: For from the Focus to the Extremity of the leſſer Axis, is a *Mean* between the greateſt Diſtance, when the revolving Body is in the *upper Vertex* (or fartheſt Extremity of the greater Axis) and the leaſt Diſtance, when it is in this *nearer Vertex*.

*M.* Let me conſider a little this laſt Particular.—The middle Diſtance then muſt be equal to half the greater Axis: For if I add the Eccentricity to half the greater Axis, that makes the greateſt Diſtance from this *lower Focus*; and if I take away the ſame Eccentricity from half this Axis, that makes the leaſt Diſtance.

*P.* You are perfectly right. And this is all that is neceſſary to trouble you with at preſent.

*M.* Theſe particulars I can eaſily remember. But ſomething you inſinuated in your De-

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Description of the Ellipsis appears quite strange, and is more than I expected.

*P.* What was it?

*M.* That a Body may move in the Perimeter of an Ellipsis, by the Composition of an attractive and projectile Force, either when the attracting Body is in the Center of the Ellipsis, or in one of its Foci.

*P.* The revolving Body must describe an elliptical Orbit, as well in the one Case as in the other, according as the Law of Attraction is supposed different; which perhaps you may understand hereafter, if I can hit upon an easy Way of communicating these Things to you.

*M.* I am to the last Degree impatient to hear this: For, if I might speak my present Sentiments, the Thing seems to me utterly impossible.

*P.* In the mean Time it would not be amiss to acquaint you with another Particular though it be not absolutely necessary; and I am afraid it may be difficult too.

*M.* Pray tell it me at a Venture: The more preparatory Things I have, the more easily I shall understand what follows.

*P.* If a Body revolve about a Center, by the Composition of an attractive and projectile Force, and if a Line from the Center to the Body

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Body be ſuppoſed to move along with the Body, that Line will ſweep, or run over, equal Spaces in equal Times.

*M.* You mean, if we ſuppoſe the Time divided into Minutes, or ſmall Portions, the Line in any Minute will ſweep over a triangular Space, which will be equal to the triangular Space it runs over in any other Minute?

*P.* That is the Thing.

*M.* So far then I think I underſtand, that if a Body be ſuppoſed to move along a right Line with an equable Celerity, if we take any Point without that Line, and imagine Lines drawn from that Point to the Body, at the end of equal Times, the Triangles muſt all be equal, as having equal Baſes and the ſame Height.

*P.* Then you have got over the Difficulty of this noble Theorem; for it is founded upon what you have ſaid.

*M.* Could you ſhew me a Figure to help me a little?

*P.* Here is a large, intelligible Figure; and the Thing explained in Words.

*M.* Let me read and conſider this.

*P.* Don't be in a Hurry; but go through the Argument at Leiſure: You are under no Obligation to underſtand theſe Matters at firſt Glance.——

*M.* What

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*M.* What I have hitherto seen is not difficult.——I think I conceive the whole. It depends on two easy Propositions in *Euclid*: And as to the Body's moving in the Diagonal of a Parallelogram, when urged by two different Forces, I make a shift to understand that from what you shewed me concerning the Frog carried along the Diagonal of a Square, by the Composition of its own Motion with the Motion of the Plane. On the same Account it must have been carried along the Diagonal of a Parallelogram by a little Change of the Direction and Velocity of the two compounding Motions.

*P.* I find you really understand it; however consider it over again: We get larger and firmer Notions of any thing by a second Examination of Particulars.——

*M.* I fancy I understand it tolerably well, and am glad I bestowed the little Pains on *Euclid* which I did, when I find the easiest Things in that Book assist me to make out these Matters. This encourages me to be more diligent.——I see there is no begging of any thing here; one is forced to own that the revolving Body must necessarily describe equal Areas in equal Times, by Rays drawn from the Center to it; and that it must move in a Curve, if we divide the Time in very small

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ſmall Parts, and make the Triangles very narrow; ſince the attractive Force acts inceſſantly.——This is delightful! I ſee, if the revolving Body ſhould be brought nearer the Center, it muſt neceſſarily be carried about with more Celerity, that the Swiftneſs of the Motion may compenſate the Smallneſs of the Diſtance, in order to deſcribe as large an Area in an equal Time, as when it is farther off. And on the ſame Account, it muſt be carried more ſlowly when more remote; ſtill to preſerve the equable Deſcription of Areas.

*P.* Your Obſervations are very juſt, and natural: We need ſay no more on this Head.

*M.* Let me look at the Book a little, before I return it.——This is Sir *Iſaac Newton*'s own Book! Then I am not a little pleaſed with myſelf, that I have made out a Propoſition of this Great Man's, from his own Words. Here is his Picture: What a thoughtful Face is this! and how mild and ſweet too!

CXXXVIII. *P.* Theſe Things premiſed, you muſt in the next Place obſerve that a Body thrown up perpendicularly to any Height, acquires the ſame Force and Velocity in falling back again, with which it was projected.

*M.* This muſt be the Caſe, I ſuppoſe, when

when I throw a Stone perpendicularly upward; it falls back in the same Track, and with the same Velocity.

*P.* The Resistance of the Air may perhaps occasion a small Variation; otherwise the Maxim is in itself plain. For the Body receiving an equal Number of Impulses from its Gravity in ascending or descending, and those equally strong in equal Distances from the Center, whether it ascends or descends; the last will restore to it all the Force and Velocity, which the first took from it.

*M.* This is not difficult to be conceived; for since *falling* (or moving to any Point) is not the Action of Body, more than *rising* (or moving from that Point;) it must require an equal Force impressed, to make the same Quantity of inert Matter move through the same Space, whether toward, or from the Center.

*P.* And since the Space is the same, and the Efficacy of the Cause the same in the same Distances, the Time must be the same also.

*M.* So I understood it. Therefore if a Stone were dropt from a Height, and thrown up again with the same Force it had acquired from the Impulses of Gravity in falling, it would mount to the same Altitude from which

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it had firſt begun to deſcend: The Force it had acquired in falling would be ſpent in riſing, by the contrary Impulſes of Gravity, in the ſame Space and Time.

*P.* You are right: This is the ſame Caſe conſidered in a contrary View, or taken backward. And it will be equally true, whether we ſuppoſe the Body thrown up from the very Center of Attraction, and falling back to it, or from ſome Height above the Center, and falling back to that Height only.

*M.* The Reaſons already mentioned muſt be equally applicable to either of theſe Suppoſitions.

*P.* It muſt alſo be equally true, though the Body ſhould not be thrown perpendicularly upward, but with an Inclination to one Side; for if it riſe and fall through equal Spaces, it muſt loſe and acquire equal Forces, by the contrary and conſpiring Impulſes of Gravity in equal Times.

*M.* This is ſtill equally reaſonable. If I throw a Stone on plain Ground, ſo that it deſcend as far as it aſcended, it muſt have the ſame Force when it falls, as when it roſe. And if it were ſtruck back with the ſame Force it had in falling, it would, I conceive, return to me in the ſame Path.

*P.* Without doubt; for if you had thrown

the Stone from that Part at first, with the same Force, and the same Degree of Elevation, it must have moved in the same Path, from the one Side, as well as from the other. Tenth Conference.

*M.* I have often observed in playing at *Shittle-Cock*, that it was because we struck it always with equal Force, and in the contrary Direction, that it described still the same *Curve*, or *Arch* as it were, backward and forward, between each other's *Battledoor*.

*P.* The Example you bring is proper enough to assist the Imagination: And if a Stone, or any *Projectile* whatever, were still thrown back with the same Velocity, and in the same Elevation, it would describe the same Path exactly, forward and backward for ever.

*M.* This Case where the Body is projected with a Degree of Elevation, may be brought, I think, to coincide with the former, where it is thrown directly upward. For if we suppose a Plane to move equably along with an horizontal Motion, and a Body to be projected directly up from it; this Body to one not carried along with the moving Plane, will appear to be projected with a Degree of Elevation. Now if it be true with respect to the moving Plane, to which the Projection is perpendicular, that the Body

hath

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hath an equal Force and Velocity at equal Heights, both in its rising and falling; this will be equally true with respect to a Spectator off at a Side, who sees the Body really describe a Curve, or Arch. Here the Body is impelled by two Forces; one communicated to it by the Plane, with which it is equably carried along, and another by the Cause which gives it the perpendicular Projection upon that Plane. These two Forces do not disturb or confound each other; because a Spectator carried along, sees the undisturbed Effect of the perpendicular Force; and an immoveable Spectator at a vast Distance above, would perceive the undisturbed Effect of the horizontal Force. So when we throw a Body with a Degree of Elevation, the Force impressed upon it is equal to the Composition of two Forces, the one impelling it perpendicularly upward, and the other horizontally forward: And these two Forces no more disturb each other's Effects, than if the Body had a Plane moving equally along under it.

*P.* You assist yourself extremely well, *Matho*, in conceiving the separate Effects of Forces thus compounded, which are wont to perplex us in the Beginning.

*M.* I thought your Supposition of *the moving Plane and the Frog* somewhat ludicrous at

at first ; but I have found it very useful since.

*P.* But tell me, when you throw a Stone with a small Degree of Inclination to one Side, what is the Reason that it does not go on in one uniform Direction, as when you throw it perpendicularly upward ?

*M.* When I throw it perpendicularly upward, the projectile and attractive Forces act in the same straight Line ; so that there is no Force acting on any Side, to draw it out of this uniform straight Direction : But when I give it the least Degree of Inclination to one Side, these two Forces constantly act in different Directions, and the Body must constantly change the Direction of its Motion, or move in a Curve.

*P.* You will not retract this Concession afterward ?

*M.* It is a Concession you can always force me to make.

CXXXIX. *P.* Keeping these Things in your Mind, consider next how many different Curves, or *Arches* (as you call them) a Stone, or any Projectile, may describe, by the attractive and projectile Forces acting together.

*M.* It may describe very many certainly. If I throw a Stone perpendicularly up, it falls

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back in the ſame Line or Track. If I give it a ſmall Inclination to one Side, it deſcribes *an high and narrow Arch*: If I give it a little more Inclination, it will deſcribe *a lower, but wider Arch*: and ſo on. For I ſee there is no End of this Variety, ſo long as I can give it a different Inclination, and impreſs Force enough upon it, to make the Caſt different.

*P.* Where the Strength of your Arm fails, you may take into your Suppoſition a Bomb, or Cannon-Ball, diſcharged from a Piece of Ordnance; or ſomething as much above the Force of a Cannon-Ball, as that is above the Force of a Stone thrown by your Arm; or yet a Cauſe ſtill more powerful than that, *&c.*

*M.* I ſee where this muſt end. The Difference is only in *more* or *leſs*, and the Reaſon the ſame, 'till we come to the Projection of a Planet by the Almighty Arm.

*P.* Not ſo faſt: We are not there yet. ——What if you throw a Stone neither upward nor downward, but ſtraight forward, or in an horizontal Direction?

*M.* Only *one Side* of the *Arch* will be deſcribed; from the middle Point, or *Vertex*, to wit, which divides between the two Sides of the Curve.

*P.* What becomes of the other Side of the Arch?

*M.* That

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*M.* That I cannot indeed tell.——But ſtay: There muſt be ſomething under this Queſtion.——If one ſtanding on a lower Ground where the Stone fell, ſhould ſo throw it back, that it returned to the Point from which I firſt projected it, with the ſame Force, ſo that it fell on a lower Place on the other Side of me; it would then deſcribe both Sides of the Arch. Whence I ſee, it deſcribed but the Part of a Curve, the whole of which it muſt have deſcribed in proper Circumſtances.

*P.* I dare ſay, *Matho*, you have ſpoke better Senſe than you are aware of.

*M.* It may be ſo; but ſhew me how?

*P.* Without ſtaying to do that at preſent; are not both Sides of this Curve, from the vertical Point, equal and ſimilarly bent?

*M.* Certainly, when in both Suppoſitions the Stone moves from that Point with equal Force, though to oppoſite Sides: It cannot perform the one half of its Courſe in one Path, and the other in another.

*P.* Imagine now you projected the Stone with an Inclination below the horizontal Direction; and tell me what muſt follow then?

*M.* It would deſcribe only *a Piece of the Foot of the Arch*; the whole of which it would ſtill deſcribe backward, if returned with a proper Direction and Velocity.

 *P.* It

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*P.* It is ſo; the Curve would ſtill be completed, *i. e.* it would ſtill return upon itſelf, and be an entire Ellipſis, if it were not for ſome Obſtacle the Projectile meets with.

*M.* That I do not ſee, for any Projectile of this Sort muſt ſtill meet with the Earth, which ſtops its Motion.

*P.* You will ſee it gradually, by going on; and in the Interim you muſt keep in Mind likewiſe theſe ſeveral Particulars.

*M.* I ſhall not readily forget them, ſince I ſee the Reaſons all along.

CXL. *P.* Suppoſe now, as you did in a former Caſe, that the Earth were perforated from us to the Antipodes, and that a Stone were thrown perpendicularly upward from the Center, with ſuch Force, as to reach 20 Yards above the Surface on this; I deſire to know how it would move after that?

*M.* It muſt fall back to the Center in the ſame Path, or ſtraight Line, as much as a Stone thrown perpendicularly upward by my Hand, falls back on its own Track.

*P.* Would it ſtop at the Center?

*M.* It could not; for having (agreeable to the Maxim we ſpoke of) regained the Velocity in deſcending, which is loſt in aſcending; that is, the Velocity it was firſt projected

with ; it would rise 20 Yards above the opposite Surface, as necessarily as it did on this Side. And because it could no more hang in the Air *there* than *here*, it would fall back to the Center again ; and rise to us again ; and (which is strange enough ! ) it would, I see, thus continue to move forward and backward for ever ; acquiring still the same Force and Velocity at the Center, by which it would rise to the same Height here and there alternately. And still in equal Times ; for the Space being the same, and the Efficacy of the Cause the same in equal Distances from the Center, the Effect would be the same in every Respect.

*P.* All this is right enough. But imagine now that the Stone is thrown up, not from the Center, but from a Point off to one Side of it, and in a Direction parallel to the former, so that it should still rise 20 Yards above the Surface ; and in that Case how would it move ?

*M.* You suppose now the Perforation so wide, that the Stone should have free Passage all the Way ?

*P.* I do.

*M.* It would then rise to the Surface, with a small Degree of Inclination towards the Perpendicular (because now the projectile and

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attractive Forces do not act in the ſame Line) and croſſing the Perpendicular at its Extremity, or the 20 Yards Height, it would fall back again to a Point as far on the other Side the Center, as that Point was whence it was firſt projected (for both Sides of its Path muſt be equal, and ſimilarly bent) deſcribing a very high and narrow Arch indeed! This is the ſame Caſe, differing only in *more* and *leſs* (as I ſaid) as when I throw a Stone with a ſmall Degree of Inclination, to the ſame Height, *viz.* of 20 Yards. And the two Curves ſhould coincide about the *Vertex*, or in that Part above the Surface, if the Stone projected from below came up to the Point whence mine began to move, with the ſame Degree of Inclination.

*P.* You ſee then in this Caſe that your Stone deſcribes but a Part of a Curve, the whole of which it would deſcribe in proper Circumſtances?

*M.* I begin in Truth to ſee a little into the whole Affair.

*P.* But ſhould the Stone, when it falls back to the Point you mentioned on the oppoſite Side of the Center, reſt there?

*M.* It could not; for (by Virtue of the *Maxim* ſtill) regaining the ſame Force there, as when firſt projected, and having a ſimilar

Direction, it should mount up to the opposite Surface, and describe the other End of the arched Figure, or Oval, *there*; as necessarily as it did the first End of it *here*. In a Word, for whatever Reason it described the first half of the Ellipsis to our Side, for the same Reason it would describe the other Half of it to the opposite Side, or complete the whole Revolution. Nor could it stop then, but having the first Force still in that Point whence it was first projected, and the first Direction also, it must necessarily go through a *second* Revolution, and a *third*, and so on, without ceasing.

*P.* You have gone round with the whole Revolution, *Matho*, so accurately, that you have left nothing to my Correction. I was particularly pleased to find you observe so opportunely, that when the two Forces, the *projectile* and *attractive*, act ever so little in different Directions, the Body could not move in a straight Line.

*M.* As they constantly urge the projected Body in new Directions, it must incessantly change Direction, or move in a Curve; though that Curve draws near to a straight Line; for I remembred that this was the Case where you said, the Ellipsis approaches to a straight

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Line on the one *Extreme*, as it may to a Circle on the *other*.

*P.* What are your Thoughts as to the *Time* of this Revolution?

*M.* Since the Body was projected with the Velocity to reach 20 Yards above the Surface, it must come to that Height in the same Time as if it had been projected from the Center. For I saw from the Instance of the Body projected from the moving Plane, that the Effect of the one Force does not disturb the Effect of the other: The perpendicular Force raises the Body to the same Height, in the same Time, as if the Plane did not move; and the horizontal Force carries the Body the same Length and in the same Time, as if the Plane only moved; or as if there were no perpendicular Force.

*P.* I am glad you have got over this Difficulty, which was wont to give Beginners the greatest Trouble. But to return, If in any Point of this Ellipsis, the Stone were projected with the same Direction and Velocity, which it had in that Point, when it performed its first Revolution, will it not in this Case describe the same individual Ellipsis still?

*M.* Certainly: It is this that makes the Necessity of its revolving constantly in the same Ellipsis,

Ellipsis, and that without End; because, to wit, it has the same Velocity and Direction in every individual Point, as it had there at first. Or, the Velocity and Direction in any one Point is necessarily connected with the Velocity and Direction in every other Point throughout the whole Ellipsis. Hence the Projection may be made from any Point, if with the Direction and Force proper to that Point.

*P.* Let not this Reasoning slip out of your Mind again.

*M.* I shall endeavour to remember it.—

*P.* But if the Stone were projected at a still greater Distance off to a Side from the Center, still in a parallel Direction to the perpendicular Projection, and with a Force to rise to the same Height; What must ensue?

*M.* It must describe a wider Ellipsis, but touching the former in the two *Vertices*; and the Time of the Revolution will be equal to that of the former. And the same Reasoning still holds, though the Distance of the Projection from the Center be supposed still greater and greater, the other Conditions remaining the same. These Ellipses will all touch in the Vertices, their Times will be equal, and the first perpendicular Projection will be a common Diameter to them all. For there

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there is no End, I see, of the Variety of these Ellipses, growing still wider and wider.

*P.* You see in this first Case then, how possible it is that a Body may describe an oblong or oval Figure, about a Center, by the Composition of two Forces, an attractive and a projectile?

*M.* I see, *Philon*, from this endless Variety of them, that I cannot throw a Stone in any Direction, but it must describe a Part of an Ellipsis, the whole of which it would describe about the Center of the Earth (if that were pervious;) and I can hardly find Words to express my Satisfaction and Surprise, to find that so common and childish an Experiment, as throwing a Stone out of one's Hand, should shew us the Truth of a Proposition, which sounds at first like an Impossibility. But upon Reflection, I see it must necessarily be so: It is this that makes a Stone, or any Projectile describe so regularly a Part of this Figure, *here*, at the *Antipodes*, or in any Part round the Earth. In short, the *Action* of *Falling*, which you so warmly recommended to my Observation at our first Interview, contains in itself the whole Mystery of this Affair. The Body is always either falling, or rising by the Impetus it hath acquired in descending, till that be spent; and

and then it is in the Circumstance of descending anew. 

CXLI. *P.* Let us stop here a little then, and look back: For it will not be amiss to observe, that when the Stone is supposed to be projected perpendicularly upward from the Center, it must perform its Course backward and forward, or run twice over the whole Diameter of the Earth, in an Hour and about 25 Minutes. And a Revolution in any one of those Ellipses, whether narrow or wide, will (as you rightly observed) take up precisely the same Time; till they become so wide, that the last of them coincides with a Circle at the Surface of the Earth.

*M.* You shewed me indeed a little before, that a Body must revolve at the Surface of the Earth in that Time; or performs 17 Revolutions in 24 Hours, that it may have a centrifugal Force equal to its Gravity. And now I see the Connexion, with Respect to the Equality of Time, all along through the intermediate Ellipses, 'till we come to the perpendicular Projection through the Center.

*P.* You have thus a right Notion of this Matter: But you will be still more surprised when I tell you, that, if a Body were projected from the Center but half Way up to the

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the Surface, or a 4th Part only, or an 8th Part, or even but a Mile; it would ſtill take up the ſame Time (an Hour and 25 Minutes) to perform its Courſe forward and backward; or to perform a Revolution in an Ellipſis, or Circle, deſcribed on any of theſe different Heights as a Diameter.

*M.* Would a Body take as much Time to riſe and fall through a Projection of a Mile's Height, as through one of 4000? Or to revolve in a Circle of 2 Miles Diameter, as in one of 8000 Miles Diameter?

*P.* Exactly the ſame Time, in this Caſe?

*M.* Shew me, I pray you, how this could be?

*P.* I ſhall endeavour to make you conceive it in ſome Meaſure, as it has Relation to what we are going to ſay.——Firſt you muſt know, if a Body were placed within a hollow Sphere of attracting Matter, it would remain wherever it were placed, without moving to any Side. For though it were placed nearer to one Side of this hollow Sphere than to the other, the Matter attracting it on the oppoſite Side would be as the Square of its greater Diſtance: So that the Attraction increaſing as much on Account of the Matter, as it decreaſed on Account of the Diſtance, the Body would be in Equilibrio, wherever

it

it were placed within the Sphere; or if it were set a moving, it would move on equably, without Acceleration.

*M.* This I think I have some Notion of; for if the Body were placed exactly in the Center, it could then move to no Side, being equally attracted to all Sides. And if it were removed from the Center, nearer to one Side, the Quantity of Matter it receded from, must be greater than the Quantity of Matter it approached to, and would therefore keep it in Suspence.

*P.* It is greater in the Proportion I mentioned, which admits of an easy Proof, if it were worth the while to leave what we are upon at present for the sake of that.

*M.* You will shew me afterward where I may meet with this Proof; and in the mean Time please to go on.

*P.* If a Body then were placed on the Surface of the Earth, it would be attracted by all the Matter in the Globe: But if it were placed below the Surface (suppose a 1000 Miles) it could not be attracted by the Matter above that Height (for a 1000 Miles Thickness round about) more than if so much of the Globe were taken quite away.

*M.* I understand: The Body is, as if it were placed within a Crust of 1000 Miles Thick-

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Thickneſs, which could attract it no Way; or, it would only be affected by the Matter below that Depth.

*P.* And if it were 2000 Miles below the Surface, it could only be attracted by the remaining Matter of the Globe, and by none of the Matter within 2000 Miles of the Surface any where round.

*M.* This is but the ſame Caſe: I ſee were the Body placed within a Mile of the Center, it would only be attracted, as if the Globe were but a Mile in Radius, all the Matter above that urging it no Way. But what follows from all this?

*P.* Wherefore in the perpendicular Deſcent of the Stone, the attractive Force you ſee is always as the Diſtance between it and the Center, or as the Space to be gone over. When the Space is twice as great, the accelerating Force is twice as great; when the Space is but a 4th Part, the Force is only a 4th Part. If the Space be but a Mile, or one 4000th Part, the Force will be exactly in that Proportion.

*M.* I am impatient for your Concluſion from this.

*P.* Whence, be the Space little or much, it muſt always be run over in the ſame Time; for twice the Space will be run over with

with twice the Celerity, in the same Time as half the Space with half the Celerity; or as a 4000th Part of the Space with a 4000th Part of the Celerity.

*M.* Let me consider this in my own Way.——

CXLII. When the attracting Globes are of equal Density, the Gravity on their Surfaces is as their Semi-diameters, or Distances from the Centers: Wherefore the Gravity to the Center, at any Depth in the Earth, must be as the Part of the Semi-diameter to be run over. Thus far is plain.——I divide the whole Semi-diameter into a certain Number of Parts, and the half of it into the same Number of Parts: Any Part in the first Division will be double any Part in the second Division; because the Whole is double the Whole. This likewise is plain.——The Attraction at the Surface, in the beginning of the Motion of two falling Bodies, is double the Attraction at half that Distance: Wherefore a Part of the first Division will be run over in the same Time as a Part of the second Division, though the one Part be double the other.——The upper Body has now double the Velocity of the under Body; it likewise receives a new Impulse of Gravity doubly stronger

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ſtronger than what the other receives: This will cauſe the next Part in either Diviſion to be run over in the ſame Time. It is ſo every where: The upper Body has always double the Velocity of the under Body, and receives every where a doubly ſtronger Impulſe to increaſe it in that Proportion.——The Argument is the ſame, if I had ſuppoſed the lower Body to have but a third Part of the Semi-diameter to run over; the upper Body muſt in any Part of its Deſcent have had triple the Velocity of the *lower*, and every where have received a triply ſtronger Impulſe, to maintain the Velocity in that Proportion.—Now, *Philon*, I am ſatisfied in this Particular with great Pleaſure. A Stone, when projected but a Mile up from the Center, muſt take as much Time in returning to the Center again, as when projected four thouſand Miles up, or to the very Surface.

*P.* This you have examined very minutely. You may likewiſe remember, when we were ſpeaking of the various Laws of Attraction, which the *Creator* might have inſtituted in our Syſtem, we mentioned *that*, where the centripetal Force, or Gravity, was ſuppoſed to increaſe as the Diſtance from the Center of Attraction; and the centrifugal Force, in order to balance it, was alſo to be increaſed as the Diſtance.

*M.* I

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*M.* I remember the Case distinctly.

*P.* But in the present Case you see the Attraction is encreased as the Distance of the Stone from the Center of the Earth: Therefore if it were to revolve about the Center of the Earth in Circles at different Distances; *ex. gr.* so that the Radius of an exterior Circle should be twice the Radius of an *interior*; that it might have double the centrifugal Force in the exterior Circle, to balance the double centripetal Force, it must move with double the Celerity as in the interior Circle; and therefore perform a Revolution precisely in the same Time.

*M.* These were the very Conditions, and this the Conclusion the Matter was brought to: So that if this Law had obtained in the solar System, all the Planets (the uttermost *Saturn*, and the innermost *Mercury)* must have revolved about the Sun in the same Time exactly.

*P.* Hence therefore in the present Case, a Body would revolve about the Center of the Earth, in a Circle whose Radius were a Mile, or an hundred Miles, or a thousand Miles, *&c.* all in the same Time. *viz.* an Hour and 25 Minutes.

*M.* This is extremely obliging, to shew me these agreeable Speculations as we go along.

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*P.* To bring what we have ſaid more within the Reach of being applied to our preſent Purpoſe, if we ſuppoſe that this were really the Law which obtained in the ſolar Syſtem——

*M.* Pray interrogate me on this Head, to ſee if I can give you proper Anſwers.

*P.* With all my Heart. If this then were really the Law which obtained in the ſolar Syſtem, and if two Planets revolved about the Sun, the one at 4 times the Diſtance of the other, in what Proportion ſhould their Celerities be?

*M.* The Celerity of the *exterior* ought to be 4 times greater than the Celerity of the *interior*, to give it 4 times a greater centrifugal Force.

*P.* But if it were projected with more than 4 times the Celerity of the *interior*, what would enſue?

*M.* It could not then move in a circular Orbit, but would mount higher and deſcribe an Ellipſis about the Sun, equal Portions of which would lye to oppoſite Sides of the Sun; juſt as the Stone did about the Center of the Earth; for the Law of Attraction is now by Suppoſition, the ſame in both Caſes. As the Sun is placed in the Center of this Ellipſis, the revolving Body would be neareſt him when

when in the Extremity of the leſſer Axis. There it would move with the greateſt Celerity, as the Stone did in moving by the Center of the Earth. In the Extremity of the greater Axis its Celerity would be leaſt of all, that the *Areas deſcribed in equal Times might be equal:* For thus it was with the Stone when it came up to the *Vertex* of its Curve.

*P.* What if the Planet were projected from the ſame Point with a ſtill greater Celerity?

*M.* It would mount higher above the Sun, or deſcribe a more oblong Ellipſis, which, as well as the former, would touch the circular Orbit in the Point of Projection, and in the Point oppoſite to that. And the ſame Reaſoning holds, if we ſhould ſuppoſe it projected ſtill with a greater Degree of Celerity, from the ſame Point always: Nor is there any End of the Variety here.

*P.* But is there no Hazard, if the Velocity with which the Body is projected be very great, of its flying out through the celeſtial Spaces, without returning again?

*M.* None at all: Let the Planet riſe ever ſo high, it muſt deſcend towards the Sun again, and deſcribe the other half of the Ellipſis to the oppoſite Side; ſince by Suppoſiti-

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on the centripetal Force becomes the ſtronger, the greater the Diſtance is.

*P.* What would happen if the Projection were made from another Point exterior to the former, and with a greater Celerity than what would be ſufficient to make the Planet revolve in a Circle at that Diſtance?

*M.* It would deſcribe Ellipſes, ſtill riſing higher, the greater the projectile Celerity were ſuppoſed to be: All which Ellipſes would have the Sun for their common Center. And this Argument is equally applicable to any Point we can name: Nor is there any End to the Variety of Nature, and Bounds of Poſſibility, that is to the Extent of Omnipotence, which ſoon ſwallows up the Imagination.

*P.* But what do you ſay as to the periodical Times in all theſe infinite Ellipſes?

*M.* They would all be the ſame to a Minute. For if we ſuppoſe a Body to be projected perpendicularly up from the Sun to different Heights; ſince (as was ſaid before, with Reſpect to the Center of the Earth) the accelerating Forces are always as the Diſtances to be run over; it muſt always fall back in equal Times, though one Diſtance ſhould be a million of Times greater than another. And this is likewiſe true if theſe Diſtances be taken equal on the other Side of the Sun, or the ſeveral

veral Lengths be made double. We have also just now seen that Planets revolving at all possible Distances from the Sun must, on this Supposition, perform their Periods in equal Times. But a straight Line is the *extreme Ellipsis* on the decreasing Side, as a Circle is on the increasing: And when the Time in a straight Line, and a Circle on that as a Diameter is the same, it must be the same intermediate Ellipsis, whether wide or narrow. Tenth Conference.

*P.* You see then it must be as natural for a Planet on this Supposition, to describe an elliptical Orbit about the Sun, as a circular one?

*M.* I see plainly the one is as natural as the other; which notwithstanding, without this Deduction, I should have thought a strange Paradox.

CXLIII. *P.* After this, we have little more to do than to make the Transitions from one Law of Attraction to another: For if we next suppose that the Attraction is inversely as the Squares of the Distances from the Center of the Sun (which is the Law you know that really obtains) you will see the Deviations from the former Case to this, not at all unnatural, but such as in Reason they ought to be.

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*M.* So far you ſhewed me before, that both the periodical Times and Celerities of Bodies revolving according to this Law are different from what they were in the laſt Suppoſition; the Squares of the periodical Times being as the Cubes of the Diſtances, and the Celerities inverſely as the Square Roots of the Diſtances. It was thus that the *interior* of our two Moons had twice the Celerity of the *exterior*, which was at 4 Times the Diſtance, and but the 8th Part of her periodical Time.

*P.* Theſe Proportions aroſe from bringing the centrifugal Force into an Equilibrium with the centripetal, in the preſent Law of Attraction: The Foundation of the next Difference will appear more obvious, which is this. A Planet in the former Caſe ſtill returned toward the Sun again, though projected with a Velocity many Times greater than what was requiſite to make it move in a circular Orbit at that Diſtance; becauſe it met with the greater Reſiſtance the higher it mounted. But it muſt be quite otherwiſe here, where the Attraction decreaſes, as the Squares of the Diſtances increaſe.

*M.* I am aware of this; for the Body, meeting with ſuch a haſty Decreaſe of Reſiſtance as it riſes, ſtill feels the greater Facility

in

in ascending; and this must necessarily have a very different Effect from the Case where it still found the greater Difficulty. In such Circumstances, it is possible, I conceive, if the Body were projected with a great Excess of Velocity, above what would make it move in a circular Orbit at any assigned Distance, that it should never turn down again, but move on towards the Region of the fixed Stars. Tenth Conference.

*P.* This is so possible, *Matho*, that if it were thrown up but with twice the Celerity requisite to make it move in a Circle at the Point of Projection, it could never return towards the Sun, but run out through those Spaces endlessly.

*M.* That makes the impressing the projectile Force in this Case an Affair of great Delicacy! But what is the least Velocity, with which if a Body were projected, it could not descend again towards the Sun?

*P.* If the Velocity with which a Body would describe a Circle at the Point of Projection, be as unit, or 1, by a Velocity as 1, 4142, *&c.* it should move in a Curve, which does not return upon itself, nor include Space, but runs out still to a greater Distance.

*M.* Then a Velocity, less than once and a half the circular Velocity, would throw the Planet quite off through the ambient Space?

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*P.* It would. But if a Velocity as 1, 4142, would throw the Planet quite without the Syſtem, it muſt return if projected with any leſs Velocity.

*M.* I ſee it muſt, ſince the Velocity you name, is the leaſt that could throw it quite off; however, at this Rate it may return from a prodigious Height; for there is hardly any fixing a Limit betwixt a boundleſs Space, and the next inferior bounded Figure: So that a Planet might aſcend, I think, to as great a Height according to this Law of Attraction as the former, and ſtill return again: Only a much more ſkilful and meaſured Force of Projection is required *here* than in the laſt Caſe.

*P.* You expreſs the Difference of the Caſes extremely well: The attempering a ſmall Force (comparatively ſpeaking) has the ſame Effect here as the Application of a vaſt Force there. However let us ſuppoſe that a Body is projected with a Velocity a little greater than 1 only, or (that we may ſpeak of ſomething definite,) with a Velocity as 1, 15; and ſince a Velocity as 1 would make the Planet revolve in a circular Orbit at that Diſtance, a Velocity as 1, 15 muſt carry it higher. And you will conceive the whole Matter the more eaſily perhaps, if you imagine that the Body

Body moves, as it were, in a Medium *denser* nearer the Sun, but which becomes always *rarer*, as the Squares of the Distances, to which the Body rises, become greater. Tenth Conference.

*M.* This indeed assists me. The decrease of Resistance must have the same Effect upon the Motion of the Body, as a Medium growing rarer in the same Degree, though I otherwise see the Strength of your Argument: The Body must rise higher from the Point of Projection, or mount above the circular Orbit, because its Velocity is greater than 1; and yet it cannot fly quite off, because its Velocity is less than 1, 4142.

*P.* Suppose then, the Body being projected with a Velocity as 1, 15, that a Diameter to the circular Orbit is drawn from the Point of Projection, but produced indefinitely without that Orbit on the other Side; and then you will likewise see, that the Body thus projected, must come to cross that Line at some Height or other, on the opposite Side of the Sun: Or, at least, you will see some Objection, which hinders you from assenting to this.

*M.* I rather see the Necessity why it must be so; for I have the whole Scheme distinctly in my Imagination, and what you say shews me half the Ellipsis is already formed.——

The

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The projectile Direction at first was perpendicular to this Diameter; that is, the projectile and attracting Forces acted upon the Body at right Angles to each other: The Body, because of its greater Velocity, began immediately to move without the circular Orbit: The two Forces acted then obliquely upon it, which made it describe a Curve without the Circle: This Curve, since the Body could not fly off finally, must come to cross the produced Diameter again, in the opposite *Vertex*, to wit; for the Diameter goes through the Center of the Sun: And then the Body has performed half its Revolution. This extended Diameter becomes the greater Axis of the Ellipsis: The Body was at the nearest Distance to the Sun in the Point of Projection; and is at the greatest Distance from him now in the other Extremity of the Axis. All the Time therefore from the Point of Projection to this Point, the Body has moved gradually with less Velocity, that the *Areas* it described in equal Times might be equal. Hence the projectile Force became more languid, as the Sun's attractive Force grew weaker. And these two Forces act now on the Body at right Angles again, in this remoter *Vertex*.

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CXLIV. *P.* You have imagined the Case perfectly well, *Matho*, and according to Nature. The slower the Body moves, the attracting Force hath the more Time to act: Therefore it bends the Curve all along, 'till at length it acts again on the Body at right Angles to the projectile Direction, and by that Means hath more Efficacy. But how doth the Body move from that remoter *Vertex?*

*M.* Being now at its greatest Height, it begins to return; and in descending its Velocity must be accelerated in the same Manner as it was retarded in ascending, by the *Maxim* we spoke of: For the Attraction to the central Body, which in its Rising hindered it, now conspires with it, and is equally strong in equal Distances. Hence it must describe the other half of the Ellipsis, similar and equal to the first, and in equal Times. For in returning, it comes as it were into a *denser Medium*, and feels a stronger Retraction to the Center, and that inversely as the Squares of the Distances; so that it cannot run out to an equal Height from the Sun on the other Side, as in the former Case; but returns to the Point from which it first set out, with the same Velocity, and in the same Direction.

Whence

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Whence it must perform a *second* Revolution, and a *third*, and so on without End, by the same Necessity as it performed the *first*.

*P.* You have prevented me here, *Matho*, in making one material Observation, which is, that whereas in the last Case, equal Halves of the Ellipsis lay on opposite Sides of the Sun, here, on the contrary, the greater Half of the Ellipsis lyes on one Side.

*M.* I saw it was impossible that two such contrary Laws of Attraction should have the same Effect. In the former Case the Attraction was least of all when the Body was nearest the Center; therefore the Body passed on almost in the Direction of the projectile Force, as the Stone did when moving in a narrow Ellipsis about the Center of the Earth. But *here* the Attraction is strongest of all, when the Body is nearest the Center: Therefore it cannot pass on, as in that Case, but must have its Direction most changed, or its Path most bent and incurvated in this Part. From hence I see the Truth of what you told me, *That the Deviations in this Case from the former, are such as in Nature and Reason they ought to be.*——With Respect to this a Thought occurs to me, which I believe I cannot well express to you, as it is yet but raw and undigested.

*P.* The

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*P.* The Thought will come in View as you attempt to explain it.

*M.* If we suppose the Point of Projection to be the same, and the Velocity with which the Body is projected to be the same, in both these different Laws of Attraction; we shall more clearly see the Difference of the Effects, and the *Transition* from the one Case to the other.

*P.* I believe indeed we may; go on therefore to compare them.

*M.* Supposing then the Point of projection and Velocity the same; in the last Case, because the Attraction is weakest nearest the Sun, that is, at the Point of Projection, the Body will move forward almost in the same Direction; or, if we may borrow the *Points of the Compass*, to denominate the Situation of the Ellipsis, it will lye from *South* to *North*, for Instance; and the circular Orbit, which the Planet would describe at that Distance, will lye in the Middle of the Ellipsis; the Sun being in the common Center of both Curves. But in the present Case, because the attracting Force is strongest at the Point of Projection, where the Body is nearest the Sun, the Curve will be most bent there; and the Body instead of going on in the Direction of the first projec-

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tile Impreſſion, will be ſtrongly drawn about; ſo that this Ellipſis will lye croſs the other, or extend from *Eaſt* to *Weſt*. The greater Axis of this Ellipſis will coincide with the ſhorter Axis of the former, but reach a great Way farther: For the Body here will riſe to a much greater Height, as having the ſame projectile Velocity, and meeting with much leſs Reſiſtance. Whence the preſent Ellipſis will be much larger, and the ſame circular Orbit at the Point of Projection, will lye in one End of it, touching it in the nearer *Vertex*: And the lower Focus of the Ellipſis, poſſeſſed by the Sun, will coincide with the Center of the Circle.

*P.* You have already attained a great Compaſs of Thought in theſe Matters, *Matho*, when you can purſue ſuch a complicated Suppoſition with ſo much Juſtneſs and Propriety. This familiarly explains to us how, in the preſent Caſe, the Ellipſis muſt lye unequally to oppoſite Sides of the Sun, and leaves no Room for farther Doubt.

*M.* I am ſatisfied with this myſelf, becauſe I underſtand what I ſay; which I confeſs is not always the Caſe.

*P.* To ſpeak ſo as to underſtand one's ſelf is no common Advantage; which we are not at all Times ſufficiently aware of. But farther,

CXLV. Since

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CXLV. Since you see the Necessity that the Body in this Case must return to the Point whence it was first projected, with the same Velocity and Direction which it had there at first, and for that Reason perform a second Revolution, and a third, *&c.* in the same Orbit; you will likewise see, if it were projected from any Point of the Ellipsis with the same Celerity and Direction, which it had in that Point in the first Revolution, that it must revolve in the same individual Orbit still?

*M.* I see the Necessity of this as much here as in the former Case; because getting the same Celerity and Direction in any Point is the same Thing, as if the Body had been projected from the *first Point*, or *nearer Vertex* of the Ellipsis, and so come up to that Point with the requisite Velocity and Direction. In short, this is none of the Particulars in which the two Cases differ.

*P.* In order to describe, or move in this Ellipsis therefore, you see the Planet might have been projected with a great Variety of Celerities and Directions, according to the Point it was first projected from?

*M.* I see that in every Point from the *nearer Vertex*, whence we supposed the Projection made, to the *higher Vertex*, the Celerity

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rity and Direction must have been different. For in the *lower Vertex* the Celerity was greatest, and the Direction of the projectile Force was at right Angles to that of the attracting Force: From that Point to the *upper Vertex*, the Velocity grew always less, and the Direction of the two Forces became more oblique, till the Attraction began to bend the Curve towards the other Extremity of the Axis. From this I see it was the Conveniency of the Supposition, and not Necessity, that determined you to imagine the Projection made from the *lower Vertex*.

*P.* Moreover, because the small triangular Spaces, or *Areas*, described in equal Times, must be equal, you will conceive that the Celerity of the revolving Body must always be inversely as its Distance from the central or attracting Body?

*M.* I conceive this easily; for equal Triangles have their Cases inversely as their Altitudes?

*P.* You likewise remember, when the revolving Body is at the Extremity of the *lesser Axis*, it is in the middle Distance between the greatest and the least?

*M.* I remember it; and that this middle Distance is equal to half the *greater Axis*.

*P.* The

*P.* The Body therefore at that Distance will have a *mean Velocity* between the greatest and the least?

*M.* It must; for since the Velocity decreases as the Distance is increased, when the Distance is half increased from the least to the greatest, the Velocity will be half decreased from the greatest to the least.

*P.* You express it very well.——But since the Velocity at the *lower Vertex* is greater than the Velocity in a Circle at that Distance from the Focus, and the Velocity in the *upper Vertex* is less than the Velocity in a Circle at that Distance, the mean Velocity will be equal to the circular Velocity at the middle Distance?

*M.* So it seems; for in passing from a Velocity greater than the circular, to a Velocity that is less, the Body at the middle Distance must move with a Velocity equal to the circular Velocity at that Distance.

*P.* Since then the Velocity at this Point is equal to the Velocity of a Body moving in a Circle at that Distance, and since the Description of *Areas* is equable to both in the Ellipsis and Circle, the whole *Elliptical Area* will be run over by a *Ray* passing from the Body to the Focus, in the same Time as the whole Area of a Circle, whose Radius is

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equal to the mean Distance from the Focus.

*M.* I conceive it. The small triangular Area described in the Ellipsis, while the Velocity is equal to the Velocity in a Circle at that Distance, bears such Proportion to the whole *Elliptical Area*, as the small triangular Area, described in a Circle in the same Time, bears to the whole *circular Area*: And since these *like Parts* are described in equal Times, the whole Areas on each Side must be described in equal Times.

*P.* Therefore the periodical Times of a Body revolving in Ellipsis, and in a Circle at the middle Distance, that is, on half the greater Axis as a Radius, must be equal, or the same?

*M.* I see with much Pleasure it must be so.——

*P.* Lastly, from all this you will now observe, that when the Projection is made with a Velocity greater than 1, and less than 1, 4142, *&c.* it is as necessary that the Body should revolve about the Sun in such an elliptical Orbit, lying unequally to opposite Sides of the Sun; as that it should revolve about him in a circular Orbit, when the Velocity is as 1, and the Direction of the projectile Force at right Angles to the Direction of the attractive Force?

*M.* I

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*M.* I see plainly the one Case is just as natural as the other, and follows as necessarily from the different Force, or Direction, in the first Projection. All that is thought unnatural in this Case disappears, when the Consequences of these different Conditions are rightly attended to.

*P.* This is all then you wanted to know; and I suppose by this Time you will allow, that we have spent more Time and Words upon it, than the Matter was worth; as I told you from the Beginning it would be.

CXLVI. *M.* Pardon me, *Philon*, I cannot allow any such thing. We have not yet discoursed an Hour upon the Subject, and now I see the Reasons of what before I thought an inexplicable Mystery; besides many entertaining Speculations which you have acqainted me with by the way. I have not thought the Time long. Or would you have had me, for the sake of not conversing an Hour with you, to remain ignorant of those things, perhaps for all my Life. If ever I come to apply more closely to such Matters, I hope I shall conceive them more readily, for having seen the natural Reasons of Things beforehand: But if some unforeseen Accident should hinder my applying to them hereafter (which

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I hope and wiſh may not happen) I ſhall not at leaſt, from an Hour thus ſpent, be quite ignorant of them. And why do you make ſuch Haſte? This is the laſt time I am to give you any Trouble.

*P.* I know of little more that can be ſaid. You will eaſily collect by yourſelf, that there is no End of the Variety of Ellipſes, which may be deſcribed according to this Law of Attraction, more than of thoſe on the former Suppoſition: And there is a prodigious Difference alſo in the Degrees of their Eccentricity.

*M.* I ſaw before, that at whatever Diſtance we imagine a circular Orbit about the Sun, a Body might be ſo projected from any Point of it quite round, as to deſcribe an Ellipſis, which ſhould ſtill riſe to the oppoſite Side, and whoſe Plane ſhould be the ſame with that of the circular Orbit; and that this Variety might be multiplied, as we ſuppoſed the circular Orbits to lie in different Planes: But I do not yet fully conceive what you mean by different Degrees of Eccentricity,

*P.* The Eccentricity, you know, is the Diſtance of either *Focus* from the Center; and you will eaſily conceive that the *Foci* may be ſtill more and more diſtant from the Center, either when the middle Diſtance is enlarged,

enlarged, and the Ellipsis becomes greater, or when the middle Distance remains the same, and the Ellipsis is of the same Length, but varies in Breadth. In the first of these Suppositions there must be an inconceivable Variety, as we have already seen: For if the Velocity as 1, 4142 would carry off the Body to an infinite Distance, by any less Velocity than that, the Orbit must return upon itself, and include Space, or make a bounded Figure. Hence the Velocity next less than that which would throw the Body quite off, must bring it back from an immense Height. This you yourself expressed very significantly before, when you said, *There was hardly any fixing a Limit between a boundless Space, and the next inferior bounded Figure.* And accordingly, some Bodies, which thus revolve about the Sun, are supposed to take not many fewer than six hundred Years to perform their Circuit. 

*M.* This is astonishing! Such a Body must rise to an incredible Height, and have made but few Visits down to the Center of the System since the World began!

*P.* Between this greatest Height, and the least (the *lower Vertex* of the same Ellipsis, for Instance) where a Planet might revolve about the Sun in not many Days, there must

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be a vaſt Difference, and Room for many intermediate Orbits.

*M.* What muſt become of ſuch a Body, if it ſhould fly off?

*P.* Who can anſwer ſuch a Queſtion as this, *Matho?* It could not fly quite off by Chance, nor be without Deſign, if it did: But it is needleſs to ſpend Time in Things we know ſo little about.——

*M.* Pleaſe then to tell me what you mean by the other ſort of Eccentricity, where the middle Diſtance remains the ſame?

*P.* It ſerves rather to acquaint you with the periodical Times of Bodies revolving in thoſe eccentrick Orbits, than that it really obtains in Nature.

*M.* It would give me the greater Pleaſure to know a little about it on that very Account; though you have told me ſomething already concerning their periodical Times. It is often neceſſary, I find, to ſuppoſe Conditions which do not obtain, that we may the more readily conceive what is real: Thus your ſhewing me on what Conditions a Body might deſcribe an elliptick Orbit, about another in the *Center* of the Ellipſis, made me more eaſily underſtand how it might deſcribe an Ellipſis about another in the *Focus*. And without that Help, I don't know whether you could have beat it into my head.

*P.* Since

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*P.* Since the Ellipsis is described about two Points, as the Circle is about one; the *greater Axis* remaining the same, you may conceive these two Points (or the two *Foci*) to recede from each other, nearer the Extremities of *this Axis*, till they co-incide with these Extremities, and the Ellipsis becomes a *straight Line* on the one Hand; or to draw nearer one another, 'till they both co-incide with the Center, and the Ellipsis becomes a Circle on the other.

*M.* This I conceive without any Difficulty; because, as I told you, we have tried to draw the Figure all manner of ways; but how does it shew the periodical Times of Bodies revolving in such eccentrical Orbits?

CXLVII. *P.* You saw before that the periodical Time of a Body revolving in an Ellipsis, and in a Circle on the greater Semi-Axis, or middle Distance, as a Radius, is the same. Since therefore the middle Distance remains here unchanged, because the greater Axis is still the same, the periodical Times in *the Circle*, or extreme Ellipsis on the one Side, in all the *intermediate Ellipses*, and in the perpendicular Ascent and Descent through the *straight Line*, which is the extreme Ellipsis on the other Side, will still be equal among themselves.

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*M.* This is curious and entertaining. And I ſee the Reaſons we concluded from before, are ſtill applicable, let the Ellipſis become as narrow as we can imagine it, till it at laſt really become a *ſtraight Line*.

*P.* Now ſince the Squares of the Times are as the Cubes of the Diſtances, when the Bodies revolve in Circles; and ſince the Times in *Ellipſes*, and in *Circles* on their greater Semi-Axes as Radii, are equal; the Squares of the periodical Times will be as the Cubes of the middle Diſtances, as much when the Bodies revolve in Ellipſes, as when they revolve in Circles, in which the middle Diſtance only remains, and the Eccentricity diſappears.

*M.* This Regularity and Agreement is wonderfully remarkable: But what I moſt admire is the Times of the perpendicular Aſcent and Deſcent. In the laſt Caſe, the perpendicular Projections, to what Height ſoever they roſe, were ſtill gone through in the ſame Time; becauſe the Revolutions in all Circles, how unequal ſoever, were ſtill performed in the ſame Time. And here the Times of perpendicular Projections obſerve the ſame Proportion with reſpect to their Heights, as the Times in circular Revolutions do with reſpect to their Diſtances.

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*P.* You lay Things so well together in your Reflections, *Matho*, that you often help both yourself and me to right Views of them. It is certain, Harmony and Proportion run through all the Works and Laws of Nature.——

*M.* If therefore two Bodies were thrown perpendicularly up from the Sun, the second 4 times higher, for Instance, than the first; the Time of its rising and falling back, would be to the Time of the Ascent and Descent of the other, as 8 to 1, that the Square of the Time 8 might be as the Cube of its Distance 4.

*P.* You are perfectly right.

*M.* By this Method, I presume, we might find out in what Time the Planets would fall from their present Heights, down to the Center of the System, if their Motions were stopt; of which I remember you spoke before.

*P.* Very easily. The Time any Planet would take to fall down to the Sun, if its projectile Force ceased, would be half the Time it would take to revolve at half its present Distance: Or the Time of both its rising and falling would be equal to a whole Revolution in a Circle at half the present Distance.

*M.* Give

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*M.* Give me Time to think of this; for I ſhould have imagined, inſtead of falling in half the Time of a Revolution at half the preſent Diſtance, it muſt have taken a 4th Part of the Time in which it performs a Revolution at preſent, at the whole Diſtance.

*P.* Conſider then which of the two it muſt be.——

*M.* If the Planet revolved at half the Diſtance, and if the *Foci* receded from the Center to the Extremities of the Axis, the Ellipſis would become *extreme*, or degenerate into a ſtraight Line; and the Times both of revolving in the Ellipſis, and of riſing and falling through the ſtraight Line would be equal; for the middle Diſtance, or greater Semi-Axis remains the ſame: Their Halves therefore, or the Time of the perpendicular Deſcent in the ſtraight Line, and revolving in the Semi-Ellipſis, or Semi-Circle, at the middle Diſtance, would be the ſame.—I ſee it muſt be ſo.—To ſuppoſe the Time of the perpendicular Deſcent to be the ſame as the 4th Part of the Time of a Revolution in a Circle at the whole Diſtance, is to ſuppoſe that the Ellipſis degenerates into a ſtraight Line, and yet that the *Foci* ſtill keep together in the Center, which is inconſiſtent: Or it is to ſuppoſe the Ellipſis, when contracted into a ſtraight Line,

to

to have the Sun, not in the *under Focus*, or Extremity of the Line, but in the Center, or Middle of it. Tenth Conference.

*P.* You correct your Mistake very ingeniously.

*M.* More depends, I perceive, on your Way of conceiving the Eccentricity to become *extreme*, than I was at first aware of.

*P.* You saw from your own Description of the Figure, that the only Way to make it narrower was by widening the Distance between the two Pins, or *Foci*, 'till they could get no farther asunder for the Length of the Cord or String.

*M.* It was so.——In order then to try this Calculation by myself, I first find out the periodical Time of the Planet at half the Distance, by the Proportion between the Squares of the Times and Cubes of the Distances; and Half of that will be the Time of its falling directly down to the Sun, from its present Distance?

*P.* Or the Whole of it will be the Time both of the Ascent and Descent through that Height.——Now, to conclude, *Matho*; from all this you will see, though the Earth and the rest of the Planets revolve about the Sun in Orbits somewhat eccentrical, this no way disturbs the Proportion between their periodical

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cal Times and the Cubes of their middle Distances. The Earth is farther from the Sun in the Summer, than in the Winter: For from the *vernal Equinox* to the *autumnal*, is about 8 Days longer, than from the *autumnal* to the *vernal*, becauſe the greater half of the Ellipſis is then to be run over; and about the Summer Solſtice the Sun's Diameter appears ſomewhat leſs, he being then farther diſtant from us: And for all that we are not otherwiſe ſenſible of this, with reſpect to Light or Heat: Our Heat particularly holds no Proportion with the Sun's Diſtance.

*M.* I am as glad now to know theſe Things, as I was before afraid, leſt they might have diſturbed what I already knew. From hence I perceive that it is manifeſtly a Work of Contrivance and Deſign, that the Planets ſhould revolve in Orbits ſo nearly circular. The Circle is but one of the innumerable Kinds of Ellipſes: And it is perfectly wonderful that ſo many Bodies ſhould be determined to this particular Species, when it was as natural and eaſy to revolve in any one of ten thouſand others.

CXLVIII. But you ſeem to inſinuate that there are different Bodies, which revolve about the Sun in thoſe eccentrical Orbits, and aſcend to a vaſt Diſtance from him. *P.* Thoſe

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*P.* Thoſe Bodies are indeed reckoned to be conſiderably more numerous than the Planets themſelves, either primary or ſecondary; and are now allowed to belong equably to our ſolar Syſtem. They revolve, you ſee, by the ſame Forces impreſſed, and obſerve the ſame Proportions in their Motions, as the Planets do. Some of their Periods ſeem already to be determined with a good Degree of Probability: But more of them are ſtill uncertain. This is a Subject for the Induſtry of future Ages. Thoſe *Comets* (for ſo they are called) do not move according to the Order of the Signs, or from *Weſt* to *Eaſt*, as the Planets do; but often directly contrary: Nor do they revolve in the ſame Plane with the Planets, nor in the ſame common Plane among themſelves; but move through the Syſtem all manner of ways: For this depends on their firſt Projection. Conſequently their *Aphelia*, or the remoteſt Part of their Orbits, lye indifferently to all Parts of the Heavens. They all riſe above the Orbit of *Saturn*; but ſome of them mount to a prodigious Height between that and the fixed Stars. Thus *that Comet*, whoſe periodical Time is reckoned to be 575 Years, riſes to about 14 times the Diſtance of *Saturn* from the Sun; which is an amazing Height, if we conſider it in itſelf,

and

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and not as it is expreſſed in this ſmall Number.

*M.* How is this found out?

*P.* Having the periodical Time and Diſtance of *Saturn* (or of any of the Planets) and the periodical Time of this Body, by the Proportion we have ſo often mentioned, between the Squares of the Times and Cubes of the Diſtances, you may eaſily find out its middle Diſtance, or half the larger Axis of its Orbit.

*M.* I remember it: We thus find out the Diſtance proportional to any Time, or the Time proportional to any Diſtance.——And this at laſt diſcovers to me the Meaning of the Particulars concerning which I aſked you in the Beginning of our laſt Conference. The *Upward* and *Downward* with reſpect to the Sun, I ſee, or his Attraction, reaches far above the Orb of *Saturn*; ſince it extends to a Diſtance 14 times wider than the whole Planetary Syſtem. O! were it allowed us to find out what paſſes there!

*P.* Your Wiſh is prepoſterous at preſent. The Knowledge of ſome Things is as wiſely denied us, as the Knowledge of others is indulged to us.

*M.* Well.——It alſo now appears wiſely diſpoſed, that all the Planets ſhould move in, or nearly in the ſame Plane; ſince other Bo-

dies were to roam through the System all manner of ways: For thus, I suppose, their interfering, or dashing against each other is prevented. Tenth Conference.

*P.* It is certain, *Matho*, since *God* presides over all Nature, that nothing can be ordered as it is, without a wise Design. The *dismal Catastrophe* you mention is wisely prevented and perhaps by this Means. To suppose that such fatal Shocks in Nature may casually happen, or that the Planets may be liable to Decays and Dilapidations, is not, in my Opinion, right Philosophy; but looks as if we imagined Matter were governed by a *blind power*.

*M.* I come entirely into your Sentiments on this Head: But pray what is the Use and Design of those wonderful Bodies, which move thus through the System, in a Manner peculiar to themselves? Are they habitable? Why approach they so near the Sun? and then run out to such an unmeasurable Distance from him? Can there be such Bodies in other Systems? Or is ours singular?

*P.* You touch upon another signal Instance, where we ought humbly to adore and reverence a Knowledge superior to our own, even in those Things, the Use of which we are quite ignorant of.

*M.* And

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*M.* And for all that I have heard *Comets* ſpoke of in Converſation, with a certain Dread and Horror.

*P.* That is the Thing: They rarely viſit us, or rather the groſs of Mankind rarely obſerve them; therefore their Appearance has been thought ominous. Formerly they were imagined to forebode ſome great Diſaſter, or general Calamity to the Inhabitants of the Earth: And lately they have been thought to be deſigned for bringing about great and fatal Changes to the Earth itſelf, by Deluges and Conflagrations. And certainly, when beheld through the Teleſcope, they make a frightful Appearance, with long blazing Tails, and ſomething like fiery Hair about the *Nucleus*, or Star itſelf. Others think they ſerve to recruit the Expenſe of the Sun and Planets, which without ſuch Reparations muſt waſte and become at laſt uſeleſs. Others think this Expedient forced and unnatural, that a greater Number of Bodies ſhould only ſerve to repair the Decays of a ſmaller. And in Truth, all theſe Conjectures ſhew rather *that natural Impatience*, which is planted in the Mind of Man, of being ignorant, than their Ability, to find out the true Reaſons of Things.

*M.* How

*M.* How various and wonderful are the Works of God! This is a new and tremendous Scene! It is not indeed without Reason that you say, we ought to adore and reverence a Knowledge superior to our own, even in those Things whose Use and Nature we cannot so much as guess at. How dreadful is the Power of that *Almighty Arm*, which so projects these unknown Bodies that they pass without the Limits of our World;——with such measured Force, that they return from thence, instead of flying off to other Regions of the Universe;——with such Direction and Skill, that they do not dash against the Planets, and bear down the habitable Globes of our System! How far are we from the full Knowledge of Things! Or can our Desires of Knowledge ever be satisfied? Why are they so strong and natural, if the satisfying of them be impossible?—You say *they are prepostorous at present:* When will they be proper?——after we are dead? You own *there is a natural Impatience planted in the Soul of Man.* Tenth Conference.

*P.* The Sentiments of Reverence, *Matho*, which the Subject we speak of excites in you, seem to me just, and becoming; though your Expostulations are somewhat warm. But are you not afraid lest they expose you to the Raillery of your *Equals?*

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*M.* Why ſhould they expoſe me?

*P.* Thoſe, whom Birth and Fortune have raiſed above the inferior Crowd, laugh at theſe Things.

*M.* What is it then they are ſerious about?

*P. Hounds, Horſes, Dreſs, Diverſions*; and in Time, *Drinking, Gaming*, &c. &c.

*M.* I find I have no Turn for theſe great Exploits, and muſt be content with a leſs Share of Reputation than they afford.—— But with Reſpect to the Subject we are ſpeaking of, could you bear the Importunity of two or three Queſtions, for my Satisfaction, before I take my Leave of you?

*P.* Much more eaſily, I am afraid, than I could anſwer them.

CXLIX. *M.* In the firſt Place then, as preparatory to what I want to know, tell me wherein a material Syſtem aids and aſſiſts the Soul to *know* and *underſtand?*

*P.* Inſtead of two or three Queſtions, you ſeem to begin a new and laborious Subject, which we have not now Time to diſcourſe upon at due Length.

*M.* Do not fear; I ſhall bring my Queſtions within a narrow Compaſs.

*P.* You have Principles whereby you may ſatisfy yourſelf in this Affair, if you call to

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Mind what we said before, concerning the sluggish and inactive Nature of Matter. A material System is made consistent with a Degree of Life and Activity, by a wonderful Instance of Divine Power; but can no Way bestow Life or Activity, or any Degree of them, upon the Soul. When we examined Matter in all Views, we found it utterly incapable of ever becoming a self-moving Substance, even by *any Power*. To ask if the Deity could make it *such*, was to ask if he could perform a Contradiction. Such a Thing is not the Object of any Power. It is joining together inconsistent Ideas in the Brain of Man; or rather joining together Words in his Language, which express inconsistent Ideas: Such Ideas cannot be joined. Hence Matter is a *resisting impeding Substance*, as it is a solid extended Substance. Consider how deep these Things go. —— We know not, nor can we name a greater Absurdity, than that *Union* to a dead and torpid Substance should give the Soul Life and Power, or any Degree of them; or that *Separation* should again deprive it of these. The Soul therefore must be percipient and active in its own Nature, independent of Matter——Examine in your own Mind, if this be saying any more, than that *a living*

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*Being cannot owe its Life to Inertia and Deadneſs.*

*M.* It is ſatisfactory enough.

*P.* Farther, *Matho*; Matter, when beſt diſpoſed, muſt limit the Power and Activity of the Soul: And when diſordered or indiſpoſed, may quite obſtruct or impede its Operations; but can in no Manner *aid*, or *aſſiſt* its Power and Energy, otherwiſe than by *confining* and *determining* them to one Manner of Exertion. Hence the Soul, when ſeparated from Matter, muſt be freed from Indiſpoſition, and have the Confinement taken off from its natural Activity.

*M.* That is delightful!

*P.* And certain alſo; ſince the *Soul* is a living Being, and the *material Frame* a dead Subſtance, liable to Diſorder. Such a Frame, at beſt, can do no more than be inſtrumental in a limited Degree; and when the Parts of it are diſordered, the living Being languiſhes ſtill under greater Confinement. From hence proceed thoſe many equivocal Appearances, which we underſtand ſo ill, and reaſon ſo falſely upon. The Soul ſuffers from the Union, and has the Diſorders of the Frame imputed to it; while Matter is exalted above itſelf, in being made inſtrumental to the Activity of the Soul. Upon this Account we

2. aſcribe

ascribe the Life of the Soul to nothing so much as to Matter, or rather to nothing but Matter; and every Shock of the material System alarms us. They who seek a Name from Paradox and Novelty, take the Advantage of our ignorant Concessions, fortify our Fears, instead of unravelling the Subject, and triumph in the universal Loss of Being, which they threaten to Mankind. Whereas, would we distinguish carefully in our Reasonings, between two such opposite Natures, it would be easy to disappoint them. For, as I said, the great Instance of Almighty Power is, that the Soul lives and perceives in Conjunction with Matter, and not that it should live, perceive and act, when separated from *that*. What we see should remove our Doubt; the great Difficulty is already performed: Every Act and Perception of the Soul, in a State of Union, is a firm and certain Proof, though but a faint Specimen, of the active and percipient Nature of the Soul, when existing by itself, and freed from the Limitation of a dead Substance. In short, consider Matter as it is in all the Universe beside, as it is in a Stone, as it is in the Herb of the Field; the same it is in the Body of Man, the wonderful Workmanship only excepted.

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*M.* You have ſaid enough, *Philon*; I call to Mind all the Particulars you ſhewed me at large before, concerning the inert Nature of Matter. Its very Sluggiſhneſs and Paſſivity ſuppoſes the Power of the Deity conſtantly exerted in every Effect it is thought to perform. So little can it impart Life and Activity to any other Thing! I am much pleaſed in this reſpect, that we conſidered the Nature of Matter ſo narrowly, and on all Sides. My Conviction was then, and is ſtill without any remaining Scruple. And now I ſee, that every Concluſion we then made was an Argument for the ſelf-ſufficient Nature of the Soul; in Oppoſition, I mean, to its ſubſiſting by the Help of Matter, or owing any Perfection to, or borrowing Power from that dead Subſtance.——One Thing more with Reſpect to this, which you may anſwer in two Words, and I have done. What do you mean by thoſe *who ſeek a Name from Paradox and Novelty?*

*P.* In two Words, the Mortality of the Soul is but an upſtart Notion, when compared with the Knowledge of its immortal and unperiſhing Nature, which is as ancient in the World, as the Creation of the very firſt Man: Nor was it called in Queſtion for a long Series of Ages (I might tell you near the very

very Olympiad), when Men began to affect a new Reputation of Learning, from maintaining what was never heard of before. Then at length the Existence of the Deity and Immortality of the Soul began to be disputed.

*M.* You mean that these two Truths were immediately revealed by the Creator himself to the first Man?

*P.* I do; and this is as certain as any Truth in Philosophy.

*M.* I remember something you cursorily hinted concerning the Creation, in our past Discourse.——But might not these Notions have been again forgot, or fallen into Oblivion?

*P.* They never could be forgot by such a dependent Creature as Man. They might in Length of Time be disguised by idle Fables, or human Inventions superadded, (as indeed happened), but it is impossible they could ever wear into Disuse, or be lost; there are so frequent and so many Occasions to call them to Mind, in Life, and in Death. The Indefeasibleness of these two Principles is owned, or rather clearly proved, by some Authors, who notwithstanding contend that there are whole Nations of original Atheists, without any Notion of, or Name for *a Supreme Being:* So that you may easily allow, it cannot be denied.

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*M.* I begin to see the Reasons why such Notions, once broached in the World, must be conveyed down to all Posterity. But then if it be certain that they were revealed to the first Man, it is hard to conceive that there should be any where a Nation of Atheists: For all Men must have descended from him, and these Notions have been propagated together with the Species.

*P.* You have Reason so to say. Atheism and Irreligion is not the Vice of Ignorance, but of misapplied Knowledge. * And that there should be whole Nations of original Atheists is contrary to the Reason and Nature of Things; unless we will suppose that Men at first grew out of the Ground, in different Parts of the Earth, some upon the Banks of the *Tanais*, and others among the Flags of the *Nile*.

*M.* You bring to my Mind the old Dispute between the *Scythians* and *Ægyptians*.— These short Hints you have now suggested, I must consider by myself hereafter; but to come to the Particulars I principally intended, tell me,

CL. Is it possible that a Man might not

* See *Ælian*'s various-History, Book II. Chap. 31. Οἱ μηδεὶς τῶν Βαρβάρων ἀθεος.

be

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be delighted with the Knowledge and Contemplation of the Works of Nature, which we have been discoursing about?

*P.* It is directly impossible that a rational Being could be indifferent, or unconcerned about them. We are carried by Reason itself, the commanding Part of our Nature, to the Admiration and Study of those Works. A natural Curiosity, no Footsteps of which is to be seen among the inferior Creatures, at first engages us, (so artfully are they contrived to catch the Soul with Wonder!) and this is soon improved into a rational Pleasure. And since they are the Works of the Deity, by how much the more we see the Power and Wisdom displayed in them, so much the more must we admire and reverence their Author. But farther, they were set forth purely with this very Design; for you saw before, *That all Things were made for the Sake of rational Beings.*

*M.* It is inconteſtable that what is of less Dignity, must always be referred to the Use of that which is more noble; and Reason is the highest Perfection among Creatures.

*P.* He therefore, who has not a Taste for this rational Pleasure, must have his Mind pre-occupied, and engaged in lower Pursuits.

*M.* And

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*M.* And he, who follows the Dictates of Reaſon, muſt always wiſh for a more perfect Knowledge of the Works of Nature?

*P.* Certainly: Inſomuch that he cannot diſengage himſelf from this Deſire, otherwiſe than by firſt enſlaving his Reaſon, and making it ſubſervient to inferior Views.

*M.* Will this endleſs Deſire of Knowledge be always ſatisfied?

*P.* Put the Queſtion thus, *Matho*; *Will God, who is the ſupreme Reaſon, ultimately gratify the rational Deſires of his Creatures?* and then try if you can doubt of it.

*M.* Hence then the Soul muſt not only be immortal, but endleſſly happy?

*P.* And endleſſly advancing in Happineſs alſo; ſtill going forward in the Improvement of its Nature, and the Knowledge of the Perfections of its Creator. Whence (if I might uſe the Expreſſion) the Relation between the Deity and the rational Soul ſtill becomes ſtronger. For it is altogether contrary to the *Eternal Reaſon* (which Truth you ought to have ſtrongly imprinted on your Mind, as a Cure againſt the Fear of Death, and a Comfort in the Miſeries of Life;) it is, I ſay, altogether contrary to the *Eternal Reaſon*, that by how much the more perfect the rational Soul becomes, it ſhould be ſo much the near-

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er to becoming nothing. Which Absurdity must nevertheless take Place, if it were to have an End. Hence the longer it lives, the less it can die. Tenth Conference.

*M.* O! pleasing Truth! Happy Condition of the rational Nature!

*P.* Suppose, *Matho*, for a skilful Artist does nothing rashly, designs nothing in vain; suppose that the Deity, through all the Lapse of past Ages, has supported the Universe by such Miracles of Power and Wisdom, only that he might at last please himself, with letting it fall to Pieces, and enjoy the Spectacle of the Fabrick lying in Ruins.

*M.* Can I harbour such a Thought of the Deity! Or suppose this a Design worthy of infinite Wisdom!

*P.* Suppose at least, that the Deity will utterly cut off *that Nature*, for whose Sake he created the Universe; the material Fabrick itself still remaining.

*M.* This is still more against the Nature of that Being, who is the *Eternal Reason*, to abolish the rational Part of his Works, and cherish a Heap of Matter!

*P.* Can there then be a greater or stronger Security for the Immortality of the Soul, than the *immutable* Nature of the Deity?

*M.* I see, *Philon*; I see the happy Condition of the rational Nature! Eternal Reason that cannot yield to Time or Accident, to Sickness or Death, and the *Divine Nature* that cannot change, are the firm Pledges of its Immortality! You have made me as secure, as if I were already among the *Blessed*, and in the Possession of Joys beyond the Grave. This is the only *Amulet* against the Fears of Death, and Evils of Life. The Nature of the Soul, and the Design of the Deity in creating it such now appears.

CLI. *P.* Let those Men consider this, *Matho*, who are such zealous Partisans for the Mortality of the Soul.

*M.* It surprises me much that any Man should shew his Zeal in defending such a Nation, or be so much an Enemy to himself as seriously to wish it true.

*P.* You may soon meet with such Books where the Notion is defended.

*M.* I should hardly think them worth the Perusal; for it seems to me a direct Contradiction that any Man should be in love with *being Nothing*, because then he could have no Desire remaining for any Thing else. It is, I think, in Consequence of our Love of Existence, that we desire any other Thing whatever,

ever, that we wish one thing rather than another, and consult our Reputation even after Death. Why should a Man who wishes to be nothing care for what might happen, or for what might not happen, hereafter? Or even before? He can have no Interest in any Events, provided he be cancelled out of Nature. The only consistent Action he could go about, were immediately to put an End to his Life, and do all in his Power to get rid of *Being*. In short, as Things appear to me, the Desire of Existence is the Foundation of all our other Desires, and of all our *Endeavours*: Otherwise let me see what it is a Man should wish or struggle for, who wishes to have no Relation with Beings, or their Actions; or any Thing in Existence? To wish that the Relation with Things existent should continue, and to lose Existence at the same Time, is repugnant.

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*P.* You shew extremely well, *Matho*, not only the shameful Falshood that lurks in the Soul of a Man, who shews a Zeal in propagating this Notion; but the express Contradiction that a Man should be concerned for any Thing, whose greatest Concern it is that he himself should be nothing. The greatest Concern, I say; for if any other Concern could be greater, that must be for Things in Exist-

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ence: Non-existence has no Concern belonging to it. And if he had a greater Concern about Things in Existence, he must, by the Excess of his two Desires, wish to exist himself, that he might contribute his Endeavours, or participate the Pleasure of the Success. You remember the last desperate Comfort of the *Carthaginian* Queen; *Omnibus umbra locis adero*;——No Man ever wished to be totally extinguished in Death, who had any Concern about posthumous Events.

*M.* I remember likewise the Story, how the Shame of being exposed naked after Death hindered the *Milesian* Virgins, I think, from putting an End to their Lives, when nothing else could. Nor can I conceive how any Person could throw aside all Concern for his posthumous Reputation. Which shews, not only that he does not wish, but that he does not suppose he shall be quite extinguished in Death. And though it should be said, that this is but a groundless Prejudice which Men fall into, yet it shews that the Desire of being always *Something*, and the Presumption that we shall always be *Something*, is so much the stronger.

*P.* The Disingenuity of these Men's Zeal appears also from thence, *Matho*, that Non-existence is really nothing, and so cannot in

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the Nature of Things be the Object of Desire: All the Objects of Desire lye clearly on the other Side. It may be said, it can as little be the Object of Aversion; but the Good it would deprive us of makes it as much the Object of Aversion, as *a real Evil* can be.

*M.* The Consequence is plain.

*P.* Since therefore we can only desire *Something real*, that is, Existence and Pleasure; since this is the Law of our Nature, and equal to a physical Necessity; we cannot be so constituted by the Author of our Nature, as necessarily to desire one Thing, and be designed for another, which is the direct contrary of it. Had we no Desires at all, or rather were we cloyed with Existence and disgusted with Happiness, that would shew that we were designed for utter Extinction: But it is repugnant that Happiness should be disgusting, or other than the Object of Desire.

*M.* From what you say it seems to follow (and I see it must,) that Misery and Pain are the only Objects of Aversion in the Nature of Things.

*P.* You are very right: And from this again it will likewise follow, that they only, who fear the bad Consequences of a misspent Life, can wish for a total Death. And this,

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this, when you have examined Things on all Sides, you will find to be the only Caſe wherein it is poſſible to wiſh to be utterly cut off: But it is in vain; the Law of our Nature is as immutable as Fate. Puniſhment is as unavoidable in the one Caſe, as Happineſs is certain in the other.——This likewiſe is poſſible (ſo perverſe is Man!) that ſome may ſtrongly contend for the Mortality of the Soul, out of Vain-Glory; though at the ſame Time their Nature ſhrinks back at the ſerious Thoughts of it. And though ſome ſhould puſh this Affectation ſo far as to make it a Point of Honour, to appear conſtant to the laſt, for Fear of bringing a Diſrepute upon their Character, or their Principle (as is reported of the famous Atheiſt *Spinoza*;) yet this ſhews the Inconſiſtency of their Thoughts, or rather the Perverſeneſs and Diſingenuity of their Hearts, to pretend a Concern for their Reputation, and a Fondneſs of being nothing at the ſame Time. So that there is nothing but Perverſeneſs and Contradiction on this whole Side of the Queſtion.

*M.* Thoſe Men, I think, affect the Reputation of *Parricides*, or of a Crime for which Language has not a Name; who place their Zeal in ſhewing that the rational Soul muſt

must be cut off, and that there is not a Deity to govern the World. If this were Matter of Triumph to them, what is it that could be Matter of Grief and Dejection!

CLII. *P.* On the other Hand, *Matho*, we might observe that, as it draws near to the brute and unthinking Nature, not to desire the Continuation of Existence, so the greatest the best and most virtuous among Men have shewn the most ardent Desire for the Immortality of the Soul. This is the Spring of all the virtuous Actions in Life. No Man ever died in the Cause of Virtue and Liberty, for the Sake of Truth, in Defence of his Country, or on the Account of Posterity; who had not Immortality in some Sense or other before his Eyes. *Cicero* says, *Nemo unquam sine magna spe immortalitatis se pro patria offerret ad mortem.* He observes that *Themistocles*, *Epaminondas*, all the great Men of Antiquity, and he himself, needed have given themselves no Trouble for the Sake of the Commonwealth; but adds, ——*Sed nescio quomodo inhæret in mentibus quasi sæculorum quoddam augurium futurorum; idque in maximis ingeniis, altissimisque animis, & existit maxime, & apparet facillime: Quo quidem dempto, quis tam esset amens, qui semper in laboribus, & periculis viveret?* Why

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do we ſo ſtudiouſly provide for our Children, but becauſe we think the Relation between us and them is to laſt after Death, interminately? No Man fixes a Period to his Views in this Caſe. We endeavour by great and noble Actions to deſerve well of our Country; not becauſe we wiſh ſoon to be cut off from the Nature of Things; that would be the Source of *Indifference*, of *Neglect*, of *Selfiſhneſs*; but becauſe we preſume we ſhall ſome Way or other ſtill have an Intereſt in the Welfare and Proſperity of the Survivors. It is from this ſecret Spring that the Legiſlator invents and digeſts ſuch a Syſtem of Laws, as he thinks may be eternal. He adopts the whole Common-wealth for his Off-ſpring, and upon that Account never propoſes an End of the Relation between him and them, more than a Parent does with Reſpect to his Children. He provides as far as human Foreſight can, a Remedy againſt every Emergence or Accident which he fears might prove fatal to the Community; and figures to himſelf, in the ſecret Workings of his Mind, their thriving and flouriſhing in Ages to come, without any Bounds to the pleaſing Proſpect *.—

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* Theſe ſeveral Notions will be allowed to be more authentick, when it is known they are *Cicero*'s. His Words are,——Maximum vero argumentum eſt, naturam

I need not pursue this Subject farther for you, *Matho*, your own future Observation will shew you, that the Desire of Immortality, in some Sense or other, is the Source of every great, every brave, and gallant Action among Men. Read ancient History, consider the present Times, look into the Works of the Learned, fix your Eyes on all the greatest Examples, on every the most conspicuous Person; you will find all full of this Spirit, and arising from this Desire.

*M.* What you say gives me a different Prospect of Things from what I had before. I begin to see that the Desire of Immortality in some Shape or other, or perhaps under some Disguise, is the great *Principle* that animates human Life: Or rather I ought to have seen it before, when I saw that the Desire of Existence is the Foundation of all our other Desires, and of all our Endeavours.

ram ipsam de immortalitate animorum tacitam judicare, quod omnibus curæ sunt, & maxime quidem, quæ, post mortem futura sunt. Serit arbores. quæ alteri sæculo prosint, ——quid spectans, nisi etiam postera sæcula ad se pertinere? Ergo arbores seret diligens agricola, quarum aspiciet baccam ipse numquam. Vir magnus leges, instituta, rempublicam conseret. Quid procreatio liberorum, quid propagatio nominis, quid adoptiones filiorum, quid testamentorum diligentia, quid ipsa sepulchrorum monumenta, quid elogia significant, nisi nos futura etiam cogitare. *Tuscul. Quæst.* Lib. 1.

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Hence the *loweſt*, as well as the *greateſt*, among Men, are conſtantly puſhed on by this Principle; ſince all the Proviſion that is made for Life, is plainly an Endeavour for the Continuation of Exiſtence, and not with a View to put an End to *Being*.

*P.* The Obſervation is very juſt. The Principle of Self-Preſervation always works for the Continuation of Exiſtence, and in a *reflecting Being* formally extends to the Deſire of Immortality; which therefore cannot be found in the brute Nature. This Deſire may often degenerate into a Vice, as when we think we can never make Proviſion enough for the ſenſitive Part of our Nature: It is then under a Diſguiſe, but ſtill it is at the Bottom. The Deſire is ſtill good in itſelf, and neceſſary to our Nature: But Reaſon then is made the Slave of Senſe, and perhaps the Inſtrument of Vice. In ſhort, *Matho*, This *original Deſire* ſhoots out into a thouſand different Forms of Action: In the ordinary Efforts of Life it is leſs taken Notice of, becauſe every one purſues the ſame Track; but where it ſtrikes out of the common Road, it becomes remarkable. Conſider how many different Ways Men have taken to preſerve their Memory when gone. Every one who has *Power*, or *Money*, or *Genius*, falls on ſome

some Means or other, to inform Posterity, that such a Person once existed.——*Et quatenus nobis denegatur diu vivere* (says *Pliny* the younger) *relinquamus aliquid, quo nos vixisse testemur.*

*M.* It is so; Men have contrived some Sort of Way to survive themselves in Brass and Marble; in Books, Buildings, Monuments, Pyramids, Pictures, Pillars, Inscriptions, and many more Ways than I can name. What would not Men give for Existence itself, when they endeavour to preserve the bare Memory of having existed with their utmost Industry! For it is certain that all Desire of posthumous Praise and Reputation proceeds from a Desire of posthumous Existence, if I might use such an Expression.

*P.* And in this Respect, those very Men who boast the Happiness of being utterly cut off, shew themselves equally industrious with others; whereby their Candor and Ingenuity may be judged of *. The Atheist is formed

* Thus *Lucretius*,

Avia Pieridum peragro loca, nullius antè
Trita solo; juvat integros accedere fonteis;
Atque haurire: Juvatque novos decerpere flores,
Insignémque meo capiti petere indè coronam,
Unde priùs nulli velârint tempora Musæ.
Primùm quòd magnis doceo de rebus; & arctis
Religionum animos nodis exsolvere pergo:
Deinde, quòd obscurâ de re tam lucida pango
Carmina, Musêo contingens cuncta lepôre.

*Lib.* 4. Ver. 1. The Author here builds his immortal ame on the Doctrine of Annihilation!

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in Oppoſition to his own Principles: He burns with a Deſire of poſthumous Praiſe, as well as preſent Admiration: He writes, diſputes, propagates his Principles: He cannot diveſt himſelf of the Deſire of Exiſtence: No Man ever got above that Deſire, except in the particular Caſe I mentioned to you. Therefore it is a fallacious Argument in a late famous Apologiſt for Atheiſm, to tell us how many great and learned Men have been Atheiſts *. Were it ſo, their Learning could be no Plea for their Principles; more than this Author's is for the Defence he makes for them: But in Truth Learning and Knowledge never made a Man an Atheiſt, nor never will. It is an eaſy Thing to doubt, or deny; and it is Ignorance only of *Nature* can make a Man do either in this Caſe.

* Mr. *Bayle*, when he would ſhew us how conſiderable Atheiſm is, ſays——Que ſi, ſans repeter tous les examples que j'ai deja rapportez ou dans mes Penſées Diverſes, ou dans mon Dictionaire, je vous nomme ſeulment quelques-uns des modernes, que l'on accuſe d'Atheiſme, un Averroes, un Chalderinus, un Politien, un Pomponace, un Pierre Bembus, un Leon Dixiéme, un Cardan, un Ceſalpin, un Taurellus, un Cremonin, un Berigard, un Viviani, un Thomas Hobbes; pourrez vous croire avec le Pere Rapin q'il n'y a qu'un petit Auteur de ſonnet ou de madrigal, qu'un Debauché, qu'un Courtiſan, & qu'on femme galante qui ſoient ſuſceptible de l'irreligion? Puet-on caracteriſer ainſi les Philoſophes, les Medicines, les Mathematiciens, les Humaniſtes les plus celebres? *Continuat. Des Penſ. Diverſ.* §. 18. It could never recommend *Avarice*, or any Vice, to tell what Numbers had been addicted to it.

CLIII. *M.*

CLIII. *M.* From what we have said it easily appears what the World would come to, without this enlivening Principle.

*P.* The Affairs of Men could not then long subsist. Had they a contrary Desire, every one would instantly rush upon Death as the likeliest Means to get out of *Being* : And there must be an End of the Species at once. Or, had they no contrary Desire, but an Indifference whether they existed or not, whether they were *something* or *nothing*, all the Endeavours in Life must instantly stagnate, and in a little Time utterly cease. No Man would act without a Motive of Action, having nothing desirable, nothing worth while, to put him upon exerting his Powers. If the Continuance of Existence were not a Motive (as you said before) nothing else in Nature could.

*M.* This affords us a compendious View of what we saw before only in Part ; namely, That this Desire of Existence is the only Spring of all the Industry in Life ; and therefore not only of what we do for ourselves, but of the generous Actions we do for others. If we would do no Action without it, it must be the Source of the one Sort of Actions as much as the other.

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*P.* You are right. We saw this Truth before, by Way of *Induction*, or an enumeration of Particulars: And now we see it by a contrary Sort of Argument. The Desire of Existence in a *Reflecting Being* is never bounded; but (as has been said) extends itself formally into the Desire of endless Existence. Man, having this endless Desire, is susceptible of that Affection in his Nature which we call *Sympathy*, and which may be explained by *Fellow-Feeling*, or *Compassion*. All Sympathy therefore supposes the *feeling* first in ourselves; or *Fellow-Feeling* is founded upon *Self-Feeling*.

*M.* I conceive it: Sympathy must be a Contradiction without this; as if it were said, we felt the endless Desire of Existence with another, which we do not feel with another.

*P.* From this Sympathy then (which is thus founded on the previous Desire, or Self-Feeling) Man becomes social, friendly, and benevolent: He exercises Acts of mutual Forbearance, he defers the immediate Gratification of his Pleasures, and undergoes Pain for the Sake of others: Because in this large Prospect, (and in this Prospect only) he sees there is Room for the rational Desires of all Beings to have their full Consequence, and for the Happiness of all to be made consistent.

*M.* I

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*M.* I am in love with this Deduction; one Part of it falls in naturally with another, so that it seems firm and compact. And it is doubly agreeable to see, that this Desire of endless Existence, so strong in the Nature of Man, is the Foundation of all social Virtue; of all great, brave, and generous Actions, A Passion so predominant in our Nature must be good in its Consequences.

*P.* After this therefore you will easily perceive, that those Philosophers, who lay the Foundation of Virtue in the social and benevolent Nature of Man, or in the Beauty of Virtue or the Harmony of virtuous Actions, independent of the Immortality of the Soul, and without any Regard to ourselves, raise a Structure without a Basis. If a Man be indifferent about being *Something* or *Nothing*, he would hardly exert those Efforts out of Benevolence to others, which he would not exert for the Sake of his own *Being:* Or the Existence of others could not be a Motive of Action to him, if his own Existence were none.

*M.* This is very true: But their Structure seems chiefly without a Basis in this Respect, that Man could have no Benevolence or Sympathy, without a Self-Feeling *. Thus they

* We may observe here in passing, that the Goodness of God to his Creatures is of a purer Nature than the Benevolence of Man to Man; as the Divine Bounty cannot proceed from a Fellow-feeling, or Fellow-Suffering, but is perfectly free and gratuitous.

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lay the Foundation of Virtue in the Benevolence of Man, but they leave this Benevolence without a Foundation: Therefore they leave Virtue without a Foundation.

*P.* Or we may conſider the Caſe thus, if Benevolence be our Duty, it is but our Duty in Conſequence of Exiſtence, and not in Conſequence of being Nothing. As Benevolence therefore ſuppoſes Exiſtence, it ſuppoſes our Endeavours for the Preſervation of our own Exiſtence, or a Love to ourſelves in the firſt Place; otherwiſe the Exerciſe of that Virtue, and indeed of all Virtue, becomes contradictory. So abſurd is it to make ſocial Virtue, or Virtue under any Denomination, independent of Love to ourſelves, or of Deſire of Exiſtence!

*M.* That is the Notion I had; and it gives me the greater Satisfaction as I find it ſo agreeable to my Nature.

*P.* No Man therefore could die for his Country, or for the Sake of Virtue, without a Deſire of Exiſtence, at the ſame Time that he parts with Life: From which let the Concluſion be drawn.

*M.* O pleaſing Concluſion! It is this; The Exerciſe of Virtue proceeds on the Suppoſition that Exiſtence is not confined to Life, or reaches beyond Death! From what you have

have said, it is plain that the Exercise of Virtue, nay the Support of Society becomes otherwise contradictory. The rational Nature itself, and the Practice of Virtue, leads us silently by the Hand to this Truth, and lands us, lands the most illiterate virtuous Man, on a happy Immortality, without the Noise of Controversy and Arguments.——

*P.* It is said by a great Author, *Matho*, That we ought to give up our very Being for the Sake of our Country. But first, Being is not a Thing so easily to be got quit of, though we should be willing to part with it: Our Being is not at our Disposal. And then, if we be indifferent about Existence or Non-existence, that is, if we have no Love for ourselves, this can be no Virtue: We part with a Thing for which we have no Value. Where again we see that taking away Love to ourselves takes away the Nature of Virtue. Besides, if this be a Duty incumbent on any one Member of the Society, it is a Duty incumbent on every Member in it, to part with Being; and——for the Sake of what? The Society consists but of all its Members. It is absurd to make that the Duty of *every one*, which would ruin the *Whole*: it is foolish to suppose that the Non-existence of any Being might be made the Condition on which the

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the Safety of the Society depended: And it is begging a material Queſtion to ſuppoſe that when a Man dies for his Country he becomes Nothing.

*M.* All this is obvious from what we have ſaid.

*P.* In fine then, as the Practice of every Virtue ſuppoſes Exiſtence, the Obligation to the Practice of every Virtue ſuppoſes, in the firſt Place, the Obligation to love and to defend our own Exiſtence, to which you ſee we are ſo ſtrongly carried by our Nature. Hence the Beauty of Virtue, or Harmony of virtuous Actions, or any other Pretence that can be deviſed, could fix no Obligation upon us without this Foundation. The Notion *that Virtue is its own Reward* hath been long boaſted: But this conſtitutes no Obligation. If a Man is willing to part with the Reward, he will be under no Obligation to the Practice. The virtuous Man rather will be moſt in love with Exiſtence, Or Immortality; becauſe it is of more Value to him than to another: He will likewiſe do moſt for the Sake of it, and therefore be moſt ſocial and benevolent, for the Reaſons I juſt now mentioned; becauſe, on this Suppoſition, he ſees there is Room for all rational Deſires to be gratified, and the Happineſs of all to be made conſiſtent; a Condition

Condition that cannot be met with again, if we conclude the Immortality of the Soul. And to call this a *selfish* or *interested Scheme*, by Way of Contempt, and the contrary Supposition which must have very different Effects, the *benevolent Scheme* is (to say no more) a changing the Names of Things. Tenth Conference.

*M.* Since the Author of our Nature has so constituted the Actions of rational Beings, that the Man who acts most for his own Interest acts most benevolently toward others at the same Time; the Attempt to make *Interest* and *Virtue* clash, or to settle them on separate Foundations, can never be justifiable.

CLIV. From all this I am satisfied, it must be a great Comfort to the Life of Man to consider, that the Desire of Immortality is the Source of all Virtue; that our Prospect of a *Futurity* is our only rational Security at present. A Desire which has such salutary Consequences cannot be implanted in our Nature in vain, nor remain unsatisfied.—— But pray tell me now, is it possible that a Nation of Men denying the Being of a God, and the Immortality of the Soul, could subsist together in a Society, upon their own Principles? This I the rather ask, as the Thing seems to be supposed *Fact*; and yet, if we have reasoned right it must be impracticable.

2 *M.* This

*P.* This you may eaſily ſatisfy yourſelf about: For, if you remember, when we conſidered the neceſſary Exiſtence of a Deity, we found that a Being of infinite Power, Knowledge, Goodneſs and Juſtice; or (to expreſs it in fewer Words) a Being of infinite Perfection, was neceſſary; ſince a Cauſe without Power and Knowledge (that is an ignorant and impotent Cauſe) could not have produced ſuch a Being.

*M.* I remember it diſtinctly; and therefore, that an infinitely perfect Being muſt either exiſt neceſſarily, on the one Side, or imply a Contradiction to exiſt, on the other; there is no Medium, ſince the Cauſe of ſuch a Being is ſo ſtrongly repugnant.

*P.* So we found it.——The denying of ſuch a Being therefore is equal to affirming the Impoſſibility of Power and Perfection in any Degree?

*M.* It is: The ſame Argument repeated over again ſhews *abſolutely*, that if Power and Perfection be not neceſſary they muſt be impoſſible in any Degree; becauſe they could not ſtart up from nothing, or from their Contraries, which are only *mere Negations*. And then it ſhews that, if Power and Perfection be at all neceſſary, it muſt in an unlimited Degree: For, as Impotence and Imperfection

Imperfection could not produce Power and Perfection, no more could they limit these. Impotence, as we said, could do nothing against Power, nor Ignorance against Knowledge. Therefore it is plain, that denying a Being of infinite Perfection is affirming the absolute Impossibility of Perfection in all Senses.

*P.* The Atheist therefore absolutely denies the Possibility of Power, Knowledge, Justice, Truth, Goodness, and every Perfection; since he does not leave a Difference in Nature between Perfection and Imperfection.

*M.* This is most unnatural and shocking! Yet the Consequence is plain. He takes away the very Foundation of Perfection, and therefore cannot leave a Difference between it and the Negation of it; for all is the Negation of it.

*P.* He takes away, by this Means, the Difference in Nature between *Justice* and *Injustice*, *Right* and *Wrong*, *Virtue* and *Vice*, *Truth* and *Falshood?*

*M.* He does indeed; because Justice, Truth, Goodness, *&c.* cannot be the Affections of *surd Matter*, *Emptiness*, *Chance*, *Impotence*, *Ignorance*, or any thing he leaves in Nature.

*P.* From

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*P.* From this then you may ſee, that a Nation of Men denying the Being of a God, and the Immortality of the Soul, could not ſubſiſt together in a Society on their own Principles; their fundamental Principle, being deſtructive of all other Principles, takes away the Difference between Right and Wrong, Juſt and Unjuſt; in a Word, tears up all the Laws of *Government* by the Roots. And though the groſs of Mankind do not go thus philoſophically to work, to ſhew that the Difference between Virtue and Vice is taken away by the Principles of the Atheiſt; yet (as all Men are ingenious enough to reaſon on the Side of their Inclinations, and the worſe their Inclinations, the more ingenious) they readily enough draw an equivalent Concluſion in Practice. "If there be neither God nor Religion (ſay they) nor a "future State, we may do what we liſt: "If we can by Force or otherwiſe, ſecure "ourſelves from Men, who have contrived "theſe Notions, all is as well with us as "with others, nay better." Theſe are the parallel Arguments of every Ruffian, how ignorant ſoever. There is ſuch a ſtrong Relation in Nature between Juſtice and the Puniſhment of Vice, that Atheiſm leads the moſt unlearned Mind to the Proſpect of Impunity.

*M.* This

*M.* This is terrible Work! But pray what says the Author, whom you call the Apologist for Atheism, to all this?

*P.* He makes no Difficulty to suppose, That Atheists might live together in Society, provided they had good Laws, and those severely put in Execution; which he observes, is necessary in all Societies, as well as among Atheists *.

*M.* On what Principles should these Laws be founded?

*P.* He does not say.

*M.* They could not be founded on the Atheist's own Principles; for those take away the Difference between *Right* and *Wrong*, and tear up (as you said just now) all the Laws of Government by the Roots.

* Mr. *Bayle* says (Pensées Diverses §. 191.) "Après "toutes ces remarques je ne ferai pas difficulté de dire, "si l'on veut sçavoir ma conjecture touchant une Societé "d' Athées, qu'il me semble qu' à l' égard de mœurs, & "des actions civiles, elle seroit toute semblable à une "Societé de Payens. Il y faudroit à la verité des Loix "fort severes, & fort bien executées pour la punition des "criminels. Mais n'en faut-il pas par tout?"——And again (§. 172.) "On voit à cette heure, combien il est "apparent qu'une Societé d' Athées prattiquerot les ac-"tions civiles & morales, aussi bien que les pratiquent "les autres societez, pourvu qu'elle fit severement punir "les crimes, & qu'elle attachât de l'honneur, & de "l'infamie à certaines choses." Could Vice be branded with greater Infamy than at present, when the national Principle denied the Difference between Virtue and Vice?

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*P.* Certainly they could not.

*M.* That is to say then, Atheists might live together in Society, provided they were forced to live contrary to their own Principles? Is it not?

*P.* It is.

*M.* But who should force them to live contrary to their own Principles? Or put the Laws severely in Execution? For by Supposition, there are none except Atheists in the Society. Or does he suppose that they would choose the chief Magistrate of a different Persuasion, and give him an armed Force sufficient to oblige them to act contrary to their own Tenets?

*P.* He does not consider the Thing in that Light.

*M.* How doth he consider it then? Does he suppose that they would so far relinquish their own Scheme, as to borrow the Laws of their Neighbours, who own God and Religion?

*P.* He enters not into the Discussion of any of these Particulars.

*M.* This seems to be a notable Piece of Sophistry. A Society of Atheists could neither get a System of Laws at first; nor could these Laws, though once established, be put in Execution, but in Contradiction to their own Principles. *P.* He

*P.* He supposes the *Ax* and *Gallows* would do all.

*M.* The Ax and Gallows might head and hang: But he can never suppose that the Society could have a Right to punish, upon their own Principles, since all Actions, by these, are equally good, or equally bad. And to punish on no Principle is Murder. If they could have no Laws, they could have no Punishments among them.

*P.* They might agree to this *by Compact*.

*M.* Under what Sanction? for an *Oath* has no Signification on the Atheist's Principles. Or what Security could Men give, that they would act contrary to their Principles and Belief?

*P.* The Thing indeed is repugnant in Nature. They could come under no possible Obligation of observing the Conditions agreed upon, except their own Interest: And *Interest* would be as great an Obligation for breaking the Contract, as for observing it.—This whole Affair, *Matho*, has quite another Aspect, when considered narrowly, than when only looked upon at a Distance; nor are we aware how much Society owes to Religion.—

*M.* How could a Judge determine between contending Parties? Witnesses could determine nothing: An Oath is as ridiculous

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in this Caſe, as the former. Men could not ſwear by God, who deny there is a God; nor by their Faith, who believe nothing; nor on their Truth, who deny the Difference between Truth and Falſhood.——By what ſort of Engagements could a Man be bound to another for the Performance of any thing? Why ſhould one Man believe another, if it were that other Man's Intereſt to deceive him? Or could Men become more honeſt, becauſe they believed nothing of *God*, *Religion*, and a *future State*?—Muſt the Society always be in a State of War with their Neighbours? For we cannot conceive how they ſhould enter into Treaties, or Alliances of any Sort.——What is ſaid to all this?

*P.* Not a Word by this Author, whatever may be done by others.

*M.* Have you any Thing to ſay to it?

*P.* I foreſee what Anſwers you would make; ſo it is needleſs to ſpend Time; Only

CLV. You take no Notice of the Obſervation, that Laws are as neceſſary in every Society, as they would be in a Society of Atheiſts.

*M.* Not ſo neceſſary, I hope.——But on what Principles are theſe Laws founded?—Or what ſort of Actions are they deſigned to

restrain? If a Man *steals*, *murders*, *swears falsely*, he acts against his own Profession; he acts, I suppose, consistently with Atheistical Principles: Is it not so?

*P.* Undoubtedly: For if the same Man were an Atheist, he could not act better, because he had not good Principles; but might act worse.

*M.* Would any Vice in Life cease, if Men became Atheists?

*P.* The same irregular Passions remaining, Vices must then be multiplied: For good Principles are of great Service to Society.

*M.* All Laws whatever then, for the Support of Society, are made against Atheistical Principles and Practices. As these Principles would tear up Laws by the Roots, all Laws are levelled against them. And is it not a fallacious Way of Reasoning, since every where there is a Necessity for Laws to bear down the Practices arising from Atheistical Principles, since both the Laws, and the Profession of contrary Principles, can hardly restrain these Practices; that therefore a Society of Men, having no other Principles, might subsist by good Laws impartially executed?

*P.* I do not pretend to defend this Author; yet he has a Salvo for the Difficulties you mention.

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*M.* What is it?

*P.* Being preſſed with theſe Abſurdities, he retreats to another Defence. He owns Atheiſts could not live according to their own Principles, but contends, that Men do not act according to their Principles.

*M.* According to what elſe?

*P.* He avoids being particular; but from comparing ſeveral Places together, it may be gathered, that he means, *Humour*, the *prevailing Mode*, a *particular Paſſion*, *Deſire of Praiſe*, *Intereſt*; with other Motives of that Kind *.

* Mr. *Bayle* ſpeaking of an Author who had ſhewn that, on Atheiſtical Principles, Reaſon, civil and natural Obligations, Juſtice and Virtue, were only but Words void of all Senſe, adds——"Il le prouve fort judicieuſement; mais parce qu'il n'a pas pris garde à une choſe que je crois avoir demontrée, ſçavoir que les hommes ne ſuivent pas leur principes, on lui peut objecter avec raiſon, qu'il n'a rien prové dans cet endroit-là." §. 181. And again, §. 176.—— Car s'il eſt vrai que les perſuaſions generales de l'eſprit ne ſont pas le reſſort de nos actions, & que c'eſt le temperament, la cûtume, ou quelque paſſion particuliere que nous determinent, il peut y avoir une diſproportion énorme entre ce que l'on croit, & ce que l'on fait."——And in another Place, having reckoned up a great many Actions, which, he ſays, a Society of Atheiſts would obſerve, he aſſigns this Reaſon for it.——"Soit parce que le deſir d'être loüez les pouſſeroit a toutes ces belles actions, qui ne ſçauroient manquer d'avoir l'approbation publique; ſoit parce que le deſſein de ſe menager des amis & des protecteurs, en cas de beſoin, les y porteroit."——§. 172.

*M.* Does

*M.* Does he make such Things the Rule of Action?

*P.* He says, Men make them the Rules of their Actions.

*M.* And thence he infers, that the Atheist needs no Laws at all?

*P.* That is the only Inference that could serve his Purpose: But he avoids such an open Absurdity.

*M.* This is almost above Belief!——Then there is no need of Laws at all for his Society of Atheists: This will do the Business. Nor are Principles necessary in any Society: If this be a good Reason why a Nation of Atheists stood in need neither of Principles nor Laws, it will be a Reason for all Societies whatever. But (not to take Notice that *Humour*, the *prevailing Custom*, *Passion*, or *private Interest*, are strange Things to trust the Interests of Society to) his Reason itself seems to me as false as any thing can be: For whatever a Man acts from, that is his Principle of Action.

*P.* You are certainly in the right. If he had said, Men do not act according to their *Profession*, there had been but too much Ground for the Observation: But a Man never acts contrary to his Principle; the Motive of *Interest*, *Praise*, &c. is the Principle of such Actions as proceed from them. The

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Profeſſion of a *Pick-pocket* is Honeſty: But it would be ridiculous to ſuppoſe, that he had an honeſt Principle. Therefore it is of the greateſt Importance to Society, that Men's Principle be juſt and rational. *Principle* is the Source of a thouſand virtuous Actions, the Practice or Omiſſion of which the Laws could neither enjoin nor puniſh. Would Men act according to right Principles, the Laws would have little to do. In a Word, there is as great a Difference between one who acts right for fear of the Laws only, and one who acts right from Principle, as between a cunning Rogue, and an honeſt Man.——But I hope we have now done.

*M.* Pray don't be ſo impatient.

CLVI. One Particular occurs to me, which I wiſh this Author had conſidered; namely, in what Manner a Society of Atheiſts were to breed up their Children: Whether they were to diſcover to their Children their whole Principles at firſt; that there was neither a God, nor Religion, nor a future State; that whatever they might hear ſaid concerning the Creation of the World, the Government of an *Almighty Being*, Puniſhment of certain Actions in and after Life, *&c.* were but mere Fictions: Or, that Parents might have

their

their Children more obedient and tractable, if they were to educate them in the contrary Belief. For, as far as I can see, there are unanswerable Difficulties, let us make which of the Suppositions we please ? Tenth Conference.

*P.* He says nothing concerning that Matter.

*M.* Then he has considered his Subject very lamely. One, who would shew that Atheism is consistent with Society, ought to consider all Things necessary to the Continuance of the Society : And there is nothing more essential to this, I believe, than the right Education of those who are to constitute the Society after we are gone.——Or perhaps you are amusing me all this while with an imaginary Author ; since it is hardly to be supposed, that any Man would throw out such silly sophistical Stuff, and so pernicious too in its Consequences.

*P.* I am not amusing you. You cannot converse long in the World, till you meet with the Book, or perhaps have it recommended to you. And whatever Stuff this may be, or however lamely the Author may have treated his Subject, he hath filled three or four Volumes with it.

*M.* On what Pretence ?

*P.* On

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*P.* On the Diſcuſſion of this remarkable Point, *That Atheiſm is not ſo bad as Superſtition.*

*M.* The whole Deſign ſeems to be abſurd, and the Handle affected. The Atheiſt is the univerſal Parricide——of God and Man, if I durſt ſo ſay; at leaſt in his Intention. It is not the Tendency of Superſtition to ſubvert Society; if I remember rightly what I have heard concerning the *Ægyptians* and other Nations. But let it be as much worſe than Atheiſm as he pleaſes; it no way alleviates one bad Thing, that another is worſe. It never came into any Man's Head, to run a Parallel between a *Murderer* and an *Incendiary*; or to extenuate the Crime of the firſt, becauſe, ſomething worſe might be named.

*P.* I am of your Opinion: Yet the Author ſays once or twice a ſevere Thing againſt Atheiſm too.

*M.* With what Deſign?

*P.* He makes a Merit of it, when he is charged with Partiality.——But the great Hurt, *Matho*, ariſing from ſuch Performances (which thoſe Authors either do not conſider, or do not regard) is, that though Atheiſtical Principles are aſhamed to ſhew themſelves, Atheiſtical Practice is open and confeſſed: For, as you rightly obſerved, the reſtrain-

restraining of such Practices is the great and chief Design of all Laws: Or what other Name can you give to the *Highwayman*, the *Robber*, the *Perjured*, the *cunning Oppressor*, the *Blasphemer*, &c. than a practical Atheist? How many Crimes, think you, take Birth from a secret denying the Justice, the Power, or the Knowledge of the Deity?——In short Atheism takes off the Guilt of every Villainy that ever was or ever can be perpetrated. No Principle else offers such an universal Invitation to all Wickedness. And the Endeavour to take off, or lessen the Horror every Man ought to have of such Principles, is an Attempt a sober and considerate Person will never be guilty of. Tenth Conference.

*M.* I own the Attempt seems as unaccountable to me as Atheism itself. But if a Nation of Atheists could not subsist, how is it possible for them to have subsisted, as those Authors say?

*P. Cicero* observes, that a Company of Robbers could not subsist, but on a Principle of Justice among themselves: We have not now Time to consider these Things farther; only as the Observation is unexceptionable, the Application is easy; *viz.* That a Nation of Atheists could not subsist, but on Principles contrary to their Belief. As to the real Existence

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Exiſtence of ſuch Nations, it is remarkable what the Author we have been ſpeaking of ſays, with Reſpect to the Accounts we find in Books of Travels; which is to this Purpoſe: That though we may think it an undoubted Truth, that the *Part* is leſs than the *Whole*, and that Happineſs and Pleaſure are the only Objects of Deſire in the Nature of Things; yet we ſhould be forced to give up theſe two Maxims, however certain we may imagine them, if in any Corner of the Earth the *Whole* were found leſs than the *Part*; or if Men were found, who *loved Miſery*, merely becauſe it was Miſery *

*M.* That

* —— " Mais quelque evidentes que puiſſent être " ces deux maximes, il les faudroit abandonner, ſi l'on " decouvroit dans quelque coin de la terre *un tout plus* " *petit que ſa partie*, & quelques hommes qui aimeroient " leur malheur en tant que malheur." Continuation des Penſ. Diverſ. §. 6. To own firſt that theſe Maxims are ſelf-evident, and at the ſame time to ſuppoſe that if a Traveller found them falſe, we ſhould be forced to give them up, is juſt ſaying, if a Traveller found what is impoſſible here to become a Poſſibility on the other Side of the Globe, we muſt give up the Diſtinction between *poſſible* and *impoſſible*. I ſhould rather venture to doubt the Truth of the Relation. It is almoſt equal to this, that in certain Iſlands, three or four hundred Leagues from the *Philippine* Iſles, the Inhabitants are rank Atheiſts, without the leaſt Sign of the Knowledge of a God: And yet they believe the Immortality of the Soul, a Heaven and Hell, and Pleaſures or Torments in an After-State. And then Mr. *Bayle* adds —— " Il ne faut pas com-

*M.* That is to say, if an Impossibility were found Matter of Fact! we should then be forced indeed to give up all Truth at once. If the *Whole* were found less than the *Part*,

" combattre ceci pas des raisons de metaphysique. Ces " sont *des faits* contenus dans *une Histoire très curieuse* " publiées depuis peu par un Jesuite celebre." Ibid. §. 14. One might ask here, how these Islanders should come by the Notion of the Immortality of the Soul of Heaven and Hell, *&c.* without the least Idea of Religion? For, " Ils n'avoient pas la moindre idée de Religion." It is as if he had said, A Man might have the Notion of *a Part* without having the Notion, that it was the Part of *a Whole*, or of any thing greater. A little after Mr. *Bayle* owns that the Missionaries of *China*, who all boasted to have searched the ancient Records of the Country, contradicted each other concerning the Religion of the *Chinese*; some affirming that they acknowledged a God, and others that they were all Atheists to *Confucius's* Time. —— " les uns avec le Pere le Comte la font or- " thodoxe, les auteurs pretendent que l'Atheisme a regné " dans la *Chine* jusques à *Confucius*, & que ce grand Phi- " losophe même en fût infecté." §. 28. In one Place, Mr. *Bayle*, having shewn at great length, that Religion once introduced into the World, can never again be lost, concludes, that as there are Nations which have no Religion, they must have been in that State from their first Origin. —— " Comme donc il y a des peuples qui " n'admettent aucune Divinité, il faut conclure qu'ils " ont été dans cet état des leur premiere origine, *&c.*" §. 6. And again, he says, according to his Principles, and the Christian Religion, it follows, that there never was a Nation without Religion.—— " Ne me dites pas qu'un " Chrétien se peut épargner une partie de la peine, puis- " qu' il sçait que la Religion est aussi ancienne que le " genre humain: Car même selon mes principes, il " s'ensuit de là qu'aucun peuple n'a jamais été sans Re- " ligion." §. 15.

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all the Demonſtrations of *Euclid* would be good for nothing. However one Thing is certain enough from this ſort of Argument, That if in any Corner of the Earth a Nation of Men were found to ſpring out of the Gound, like Coleworts, they would have neither a Name for, nor any Notion of a Deity.——But ſince an Atheiſt muſt deny that Religion is as ancient in the World as the Race of Men; or, ſince he denies any other Creation than this *Chance-Production*; pray how does he account for the Riſe of Religion at firſt; for its univerſal Spreading; and why Man is thus naturally a *Religious Creature?*

*P.* It is impoſſible to anſwer all your Queſtions, *Matho*;——Such a Creature as Man, ſo weak, and living in ſuch Dependence, muſt be religious, if he has but the Power of Reflection: Ignorance therefore, and want of rational Improvement will make him ſuperſtitious. As to the firſt Riſe of Religion in the World, the Atheiſt's Account of it in ſhort is this. That ſome prudent and wiſe *Law-Giver* firſt invented the Notion of a God, and the Immortality of the Soul, to frighten Mortals into an Obedience to the Laws, and to make them more virtuous, and better Members of Society, than the Laws

could do: With a good deal more to the same Purpose *. Tenth Conference.

*M.* Did one who had never heard of *God*, or the *Soul* before, contrive all this?

*P.* So the Atheist supposes.

*M.* At this rate then the Atheist owns, that Laws could not bind a Nation of Men, without the Help of Religion.

*P.* He owns this to be the Experience of prudent and wise *Legislators*.

*M.* It is enough. The Atheist is certainly the most barbarous Parricide, first to allow the indispensable Advantage of Religion to Soci-

* See *Sextus Empiricus*, lib. 9. cap. 2. Where he gives the several Atheistical Conjectures concerning the Rise of Religion. The first is, ἔνιοι τοίνυν ἔφασαν τὰς πρώτας τῶν ἀνθρώπων προσάλας, καὶ τὸ συμφέρον τῷ βίῳ σκευαμένας πάνυ συνέδους ὄντας, ἀνεπλάσαι τὴν περί τε τῶν Θεῶν ὑπόνοιαν, καὶ τὴν περὶ τῶν ἐν ᾅδᾳ μυθευομένην δόξαν. The Steps of the Invention were, They first made Laws: But these being found insufficient, they contrived the Notion of the Gods, for the more effectual restraining of Vice and secret Crimes. [where, by the way, we may again see, even according to this Original of Laws, that they were first made against Atheistical Practices, and are still necessary on the same Account.] —— πρῶτον μὲν νόμας ἔθεντο πρὸς τὸ τὰς φανερῶς ἀδικουμένας κολάζεσθαι· μετὰ δὲ τοῦτο, καὶ Θεὰς ἀνέπλασαν ἐπόπτας πάντων τῶν ἀνθρωπίνων ἁμαρτημάτων τε καὶ καλορθωμάτων· ἵνα μηδὲ κρύφα τολμῶσί τινες ἀδικεῖν, πεπεισμένοι ὅτι οἱ Θεοὶ, κ. τ. λ. The Account *Critias* (one of the *Athenian* Tyrants) gives, is the same. The Place is worth the Perusal of an attentive Reader.

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ety, and then to tell the World, it is all a Cheat!——

*P.* Here then you again see the Necessity of believing a future State, in order to our subsisting in this. An infinitely perfect Being, the Author of our Nature, could not have so constituted us, as to make the Belief of a Lie necessary to our living together here as rational Creatures. Every thing in the Nature of Man, when it is truly examined, points to the Continuance of our Existence after Death, and shews the manifold Relations, which join the present to a future State. These Relations stretch out to Ages that can never end, and carry on the Existence of rational Beings even to Eternity. The Desire of Existence (you saw) is the Foundation of all our Desires: A happy or pleasant Existence is the only consistent Object of Desire in the Nature of Things: The Desire of rational Existence and Happiness, in Opposition to sensitive Pleasure, must be rational and consistent, by the Terms: This Desire can never cease, more than rational Pleasure and Happiness can ever disgust and cloy: It cannot be conceived that the Author of our Nature, and of this very Desire, who is himself an infinitely rational Being, should not satisfy a rational Desire; or not satisfy it as

long

long as it continues to be, and to be rational; that is, to Eternity.

*M.* I see the Argument as strong as Demonstration.

*P.* These are but some scattered Considerations, *Matho*, concerning the Immortality of the Soul of Man. The Nature of our Discourse, and the Shortness of our Time, will not suffer us to pursue the Subject at just Length, and in a proper Method: But these Hints, and your own Reflections, as Age ripens, will still farther confirm you in this delightful and comfortable Speculation; which is the main End of all your Studies, all your Application, and in Truth of all Philosophy. To contract a Habit of rational Pleasure, without this Certainty, would only torture you the more.

CLVII. *M.* That would be a melancholy Situation, while we are in Pursuit of Things of an eternal Nature, to be haunted with the constant Fears of losing our own Being. The unreflecting State of the brute Animal would be more eligible.

*P.* Hence then it must be an equal Encouragement to consider, that we are engaged in Speculations, the Pleasure and Variety of which will never have an End.

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*M.* It must: Wherefore (to return to our former Subject) I now perceive why, in some Parts of our past Discourse, you put off my Questions concerning the Art in the Works of Nature, which is at present inaccessible to us, either because of its Remoteness or Minuteness; till we should be able to discover something that might shew the Accomplishment of our Desires possible.

*P.* How doth the Possibility of satisfying this Desire of Knowledge now appear?

*M.* Since we are carried by a rational Desire to contemplate all the Works of Nature; since we can only get such a Taste of this Pleasure here, as to excite and kindle our Desire; and since all our rational Desires must be satisfied; it follows, that *this Beginning* must be continued, till we at length see the Use, and comprehend the Contrivance of all the Miracles of Power and Skill, through the wide material Frame. Our interminable Existence suits well with such a Design, and shews every thing consistent. Otherwise what a killing Thought must it be, to have a View of being turned down with the Ox, while we have the immense Prospect before our Eyes! To bid an everlasting Adieu to all that which raises our Nature above Humanity, being to share the Fate of the Beasts of the Field! This

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(let me dare to say it) would be the most studied Cruelty, the most exquisite Torture of the rational Mind.

*P.* Consider what an Immortality of Ignorance would be, forced upon a rational Being thirsting after Knowledge.

*M.* You shew me how wisely it is ordered, that our Period here should be but short. The Prospect put off to Eternity would be an eternal pining in Despair. This could not be a Work of Kindness. Nor can eternal Happiness consist in Ignorance: That brings it back to something like the Gratification of Sense. It must be intellectual.

*P.* You are certainly in the right: We cannot have a consistent Notion of immortal Happiness unless it be so conditioned. And as it must be *intellectual*, it must necessarily consist in having the Power and Knowledge, the Wisdom and Goodness of the Deity gradually discovered to us. This is the only Source of rational and intellectual Pleasure. The only Source; for there is not another Nature (if I may so say) which we could apply to, or improve by. To this Purpose it is wisely and wonderfully ordered, that we should begin even by the Methods of Sense, 'till, having made the intended Advancement, that Method be antiquated, and the Design

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come to be purſued in a ſuperior manner. Theſe Wonders in the material Creation were wrought with this View, to initiate the rational Being, and raiſe it gradually to the Knowledge of *higher and greater Things*. And as was obſerved before, we cannot conceive any other conſiſtent Deſign, why the Author of our Nature at all reared the Frame, if not for the Sake and Improvement of his rational Creatures. It is abſurd to ſuppoſe that he expoſed thoſe Works of Power and Skill to inform no Being; and impious to imagine, that he wrought thus to ſolace or improve himſelf; as if he had not been ſufficiently happy without a material Structure, which he might move and direct various Ways; or, as if he had propoſed to attain at laſt the Perfection of Art, by Application and Practice. His Goodneſs only could put him upon the whole Deſign; and the Deſign cannot prove abortive.

*M.* I am ſatisfied the Deity could not have expoſed thoſe Inſtances of Divine Art for the Inſtruction of no Beings: In that Caſe the Habitation of rational Creatures needed no more Contrivance nor Ornament, than the Retreats of the wild Beaſts. A Convenience for ſenſitive Life had been all that was neceſſary or proper. And if ſuch a World could not be deſigned for Beings of a ſenſitive Nature, it could not be

be designed for the sensitive Nature of rational Beings; nor be applicable to their rational Nature in any other Respect, than by discovering to them the Power and Wisdom of their Creator.

*P.* Could our Creator then design that we should admire his Power and Wisdom, only as they were displayed on the out-sides of Things; but resolved to conceal from us the internal mysteries of Contrivance and Art, lest we should improve our Nature too much; or admire his Perfections beyond a certain Degree; or come at length to expect more than he could perform?

*M.* These are impious Suppositions.

*P.* Or where the external Wonders in Heaven and on the Earth designed to catch the Attention, and kindle up in us a rational *Longing*, with a View only to mock and tantalize our Expectations?

*M.* That would be the low, malicious Pleasure of a weak Mortal.

*P.* Or could those Wonders be perceived only by the Methods of Sense?

*M.* They could as little be perceived as wrought or effected by the Methods of Sense. A material System could no way aid the Soul either to perceive or act: A System of inert Substance limits and confines it in both, and

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may wholly impede the Exertion of its Powers. This you ſhewed me before. I have no Doubt remaining. The Deity is above Envy: He could not deſign to mock our rational Expectations: His Goodneſs was the only Motive: The Methods of Senſe are incompetent: The Soul, when freed from a dead Subſtance, hath the Limitation taken off: Neither the Subtilty of the Art, nor Remoteneſs of the Object, can be a Let to a pure Spirit:——But to the Knowledge of what *higher and greater Things* were the Wonders in the material Univerſe deſigned to raiſe us?

CLVIII. *P.* And yet Matter, however heightened by Workmanſhip, is (as you yourſelf acknowledged before) the very loweſt of Things; a ſluggiſh and inert Subſtance, utterly deſtitute of all active Power, and capable only of being paſſive. Wherefore beware leſt you imagine, that this dead Subſtance obtains the higheſt Rank in the Works of the Creator. Nothing, it is true, could be better fitted to initiate Beings, whoſe firſt Informations of Things are from Senſe, and to train them up in the Elements of Knowledge and Admiration: But the *external Frame*, the *Caſe*, can never be of equal Dignity with the Thing for whoſe ſake it

was

was made, nor an equal Instance of Skill and Power.

*M.* You recall once more to my Thoughts the several Particulars we saw and concluded concerning the Nature of this Substance. Unwrought Matter presents us with the Power of the Deity: But we can turn our Thoughts to no Species of it in the Universe, that has not gone through the Hands of the Artificer. ——It is so wonderfully made, to support our Bodies, relieve our sensitive Appetites, and convey the Notice of external Objects to the Soul, by Means of the Senses, that by considering all the Effects, without looking to the *Cause*, or reflecting upon the *End*, Matter is become the Deity of Mankind. —— But I likewise saw, that the Soul of Man, and of every Animal, is an immaterial Being; and that the different Structure of the Body, in every Species of living Creatures, is fitted to the various Powers and Capacities of this living Principle. Hence it is reasonable to allow, that the Creator has shewn more Art and Power in making this more noble Being; nor can there be less Variety in the living, than in the dead Part of the Creation.

*P.* The Works of the Deity, *Matho*, as we have often said before, constitute a certain *Scale*, or Gradation, which still rises in

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Dignity. For they are either *purely material*, or *immaterial Subſtance*, joined to an organized Body, or laſtly *pure Spirits*, free from all Contagion of Matter. Since then in the firſt two Parts of the Scale, there is ſuch an amazing Variety of intermediate Species, beginning at unwrought Matter, and aſcending to Man; it is altogether incongruous, that in the *third Order* there ſhould be no Gradation nor Variety; but that after we have once got above the Alloy and Depreſſion of a dead Subſtance, we ſhould then have riſen to the Supreme Being.

*M.* It is certainly incongruous that all above the Confines of Matter ſhould be a mighty Blank.

*P.* The Series of immaterial Beings begins with the very loweſt Animals; that is, it borders on the vegetable Kingdom, and riſes by innumerabe Steps to Man: Now what is there between *Man* and the *Deity?* —— Nothing?

*M.* The third Order ſeems to be entirely wanting, and the Scale broke off in the Middle, unleſs there ſtill remains a proportional Gradation among *pure Spirits*, ſtill riſing in Degrees of Perfection.

*P.* Since then, there are none of the Works of God, but what ſerve for the Advancement

vancement of the rational Nature; none of them secluded or hid from the rational Spectator; what Wonders of Power and Wisdom, do you think, must still remain, after we have discovered all that are above the passive Nature of a dead Substance? How much a greater Instance of Power is it, to have bestowed *Power itself*, and various Degrees of it too, upon other Beings, than to have exerted his own Power only on this passive Subject?

*M.* This I in some Measure conceive, if I compare *self-moving Engines* (as they are supposed) with any common Instrument, which requires the constant Application of the Hand. Though I am aware, that *Clock-Work* hath, properly speaking, no Power in itself. ——

*P.* Or could the Deity have bestowed Power and Agency on Living Beings, only as they were clogged with Systems of dead Matter?

*M.* Ah! Do not ask a Question so absurd! As if Matter could contribute any thing, by confining, or obstructing the Powers of a living Being!

*P.* Or could He not have imparted to them Powers above those of the human Soul, without encroaching on his own Omnipotence?

*M.* It

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*M.* It is too much, *Philon*; I see the immaterial, the spiritual, the living Part of the Creation, may rise in Degrees of Power above our Conceptions; yet without being able to approach the boundless Perfections, and self-existent Nature of the Creator.

*P.* If therefore there must be an infinite Distance between the highest created Nature, and the necessary Perfections of the Deity, the Knowledge of created Beings, or concerning created Things, must fall infinitely short of the Knowledge in the *Divine Mind*. The Connexion of eternal Ideas, which have no Relation to the Existence of any Thing, except the Mind, whose Ideas they are, are many ways, infinite ways infinite. We may still be advancing in the Perfection of our Nature, and still must be at an infinite Distance from the *necessarily existing Being*.

*M.* I see that *Necessity* of *Perfection* must infinitely prevent all possible Improvement of Perfection.

*P.* You express the Disproportion, *Matho*, justly: As an endless Addition of Minutes could never constitute Eternity, nor make the future Prospect less; so it is between immortal Beings, still advancing in Perfection, and the Deity necessarily perfect. And in this consists the eternal Happiness of rational Beings,

Beings, endlesly to acquire new Accessions of Perfection and Happiness, with an infinite Prospect still before them. Thus the Soul must flourish in the Adoration and Love of its *Maker*, through Ages that cannot end, and in the Fellowship of happy Spirits past numbering.

*M.* Nor does the Certainty of this Prospect less constitute our present Happiness; since these Reasons cannot fail, or yield, in Sickness, Danger, or Death itself.

And now, *Philon*, I shall put an end to my Questions, and the Trouble I have given you; nor shall I attempt to express in Words the Sense I have of your Friendship: But while I remember the noble Truths you have shewn me, and the Dignity of the human Soul, I cannot forget the Man who first led me through these pleasing Speculations.

*P.* This is too much, *Matho*, to your Friend. Were it true, that I had been so serviceable to you as you speak of, my Pleasure must be at least equal to yours. But you owe the greatest Part of these Discoveries to your own *Genius*, the Happiness of which I have often admired in the Course of our Conferences; for you discovered the Reasons of Things yourself, and generally prevented what I had to say.

ANNO-

# ANNOTATION

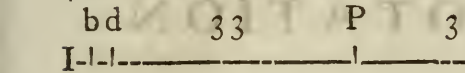
To what is ſaid in the Seventh Conference above, concerning the Point of equal Attraction between the Sun and any of the Planets; or *that Point*, where if a Body were placed, it ſhould gravitate neither to the Sun, nor to the Planet.

AS the Method propoſed in the Note at the End of the *Latin* Pamphlet, for enquiring into the Sun's Parallax, and approaching, if poſſible, nearer the Truth, has not, I humbly think, been ſufficiently conſidered; I beg Leave to tranſlate the Note here, and make it a little plainer, that what is propoſed may be ſeen with the leſs Trouble: Hoping no one will be offended, ſince I do it with no View to *contradict*, or *find fault*, but only for the Sake of what I take to be the Truth.

The Method of finding out the Point of equal Attraction between the Sun and any Planet, the Quantity of whoſe Matter is known with Reſpect to that of the Sun, will eaſily appear from an Example. Let the Line

IS

IS represent the Distance between *Jupiter* (for Instance) and the Sun.

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Upon the Supposition that the Sun's Distance from the Earth is about 21000 of the Earth's Semi-diameters, the Quantity of Matter in the Sun is to that in *Jupiter* nearly as 1089 to 1; which is easily discovered from what is shewn in N°. 131 above. The Square Root of the Number 1089 is 33. Now at an equal Distance from both Bodies, or at the middle Distance P between their Centers, their attractive Forces are as their Quantities of Matter, 1089 and 1. That is, the Sun's Attraction is there 1089 Times stronger than *Jupiter*'s. Let I b be $\frac{1}{33}$ part of I P, (or $\frac{1}{66}$ Part of the whole Distance I S;) and *Jupiter*'s Attraction at b will be 1089 Times greater than it is at P; for it is inversely as the Squares of the two Distances I b and I P. Therefore *Jupiter*'s attractive Force at b, and the Sun's at P must be equal. Then since both Forces decrease as the Squares of the Distances increase, they must come to be equal again, or balance each other, at some common Point between b and P. Let that Point be d. And since *Jupiter*'s Force at b, is to

his

his Force at d, as the Sun's Force at P, is to his Force at d; (for as the Antecedents are equal, so are the Consequents;) the Squares proportional to these Forces must also be proportional; that is, I d Square is to I b Square as S d Square is to S P Square; and, by Inversion, I b sq. : I d sq. :: S P sq. : S d sq. And (by *Eucl.* VI. 22.) I b : I d :: S P : S d. Hence, making b d = x, it will be, $1 : 1+x :: 33 : 65-x$ or $33-33x=65-x$. Whence b d or $x = \frac{32}{34} = \frac{16}{17}$. Thus I d, or $1+x$ is equal to $\frac{1}{66}$ Part of the whole Distance between the two Bodies, and $\frac{16}{17}$ of $\frac{1}{66}$ Part: But it cannot be equal to $\frac{2}{66}$ Parts, or $\frac{1}{33}$ Part of the whole Distance. For if I d were double I b, S d would be double S P; that is, d would coincide with I, which is repugnant.

Hence we may form this general Rule concerning the Point, where the attractive Force of a Planet is equal to the attractive Force of the Sun, *viz.* That it is more remote from the Planet than that Part of the Distance between the Sun and it, which is expressed by a Fraction, whose Numerator is unit, or the Quantity of Matter in the Planet; and the Denominator is twice the Square Root of the Quantity of Matter in the Sun: But it can never come to be equal to two such Parts.

From

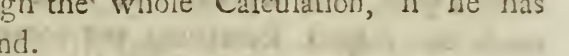
From this we may easily see that the Point of equal Attraction between the Sun and this Planet falls a great Way without the Orbit of his utmost Satellite. If the Earth's Distance from the Sun be 21000 of its own Semi-diameters, *Jupiter*'s Distance from him is about 5264 of his Diameters. And supposing the *Point of equal Attraction* between him and the Sun $\frac{1}{33}$ of this Distance, that comes to about 159 of his Diameters: Whereas his outermost Satellite is distant from his Center only $12\frac{2}{3}$ Diameters. All his Satellites therefore lye far within the Limits of their Primary's stronger Attraction; so that they must have been removed to a vast Distance from him, if they had revolved about the Sun separately, as primary Planets; as was observed above (N°. 116.) The same Way it may be found that the innermost of *Saturn*'s Moons must have revolved at a greater Distance from his Center, than 84 Diameters of his Ring, to have been without the Limits of his prevalent attractive Force; whereas the outermost of them is not above 12 of these Diameters removed from his Center. Which shews us clearly that the Bounds of the Solar System must have been greatly enlarged, had the 9 Satellites of those two Planets revolved immediately about the Sun as primary Planets. *Saturn*'s Satellites,

for Inſtance, muſt have been removed, not only without the Limit of equal Attraction between the Sun and him, but the loweſt of them muſt have revolved at a far greater Diſtance from *Jupiter*, than *Saturn* himſelf now revolves: Since if *Jupiter* diſturbs them at preſent, notwithſtanding the attractive Force of their Primary, he muſt have drawn them quite down then, when nothing but their centrifugal Force kept them in their Orbits.

This Calculation proceeds on the common Suppoſition, that the Sun's *Parallax* (or the Angle which the Semi-diameter of the Earth ſubtends at the Sun) is 10 Seconds; and therefore that the Diſtance of the Earth from the Sun is about 21000 of its own Semi-diameters. But when I endeavoured to apply the ſame Argument and Calculation to our Moon in order to diſcover how far ſhe was within the Limit of equal Attraction between the Sun and Earth, I was ſurprized to find, that, on this Suppoſition, ſhe muſt revolve a great Way without that Limit. This made me ſuſpect ſomething not commonly attended to, which will prove to us (I ſtill humbly think) that the Diſtance of the Sun cannot be near ſo great. However, I ſhall give the Calculation itſelf, that it may be examined. If

If the Sun's Parallax be 10″, or rather 9″ 54‴, his mean Distance from the Earth will be 20797, 5 of its Semi-diameters; and the Quantities of Matter in the Sun and Earth will then be as 277000 and 1; by what is said above, N°. 131. For since the Moon's periodical Time is 655 Hours 43 Minutes, or 655,716 Hours, the Square of it will be 429963,472656: And the Square of her periodical Time, if she revolved at the same Distance from the Center of the Earth as *Venus* does from the Center of the Sun, would be 660108446727 8. *Venus*'s periodical Time is 5393 Hours; the Square of which is 29084449. And the Quantity of Matter in the Sun will be to the Quantity of Matter in the Earth inversely as the Squares of the periodical Times of two Bodies revolving about them at equal Distances: That is, as 660108446727 8 to 29084449, or as 277000 to 1. This I have set down, that any ingenious Person, though a Stranger to these Things, may satisfy himself, by going through the whole Calculation, if he has a Mind.

The Square Root of 277000 is 476, neglecting the decimal Parts. Let the Line

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TS repreſent the Diſtance between the Centers of the Earth and Sun. At the middle Point P between their Centers the Sun's Attraction is 277000 Times greater than the Earth's. Let Tb be $\frac{1}{476}$ Part of TP, or $\frac{1}{952}$ Part of the whole Diſtance TS, as before; and the Earth's Attraction at b will be 277000 Times greater than at P; or it will be equal to the Sun's Attraction at P, for the Reaſon aſſigned above. Let d be the common Point between b and P, where they will again be equal; and then, as in the former Example, Tb : Td :: SP : Sd, or (making bd = x) it will be, $1 : 1+x :: 476 : 951-x$. Hence $476+476x=951-x$; and $x=\frac{475}{477}$. Therefore Tb+bd, or $1+x$ is equal to $\frac{1}{952}$ Part of the whole Diſtance $TS+\frac{475}{477}$ of $\frac{1}{952}$ Part of it; but cannot be equal to $\frac{2}{952}$ Parts, or $\frac{1}{476}$ Part of it.

Since Td, or $+x$ is equal to $1\times\frac{475}{477}$ (=1,9958) of TS, it is $\frac{1}{477}$ Part of it; for $1,\frac{9525}{9958}$ is = 477. And 20797,5 Semi-diameters divided by 477, gives 43,6. Thus Td is = 43,6 Semi-diameters of the Earth; or the Point of equal Attraction between the Earth and Sun falls within 43,6 Semi-diameters of the Earth's Center.

The Moon revolves at 60, ſometimes at 63 Semi-diameters of the Earth from its Center; in which Caſe it ſtill appears to me that

that in every Conjunction she would desert the Earth, carried off by the prevalent Force of the Sun; at least, if the Reasoning in the Seventh Conference above be just. For then we must suppose, either that she is carried round the Earth contrary to the common Law of Gravity, and on other Conditions than the Satellites of *Jupiter* and *Saturn* are carried round their Primaries; or else that both the Quantity of Matter in the Sun, and his Distance from the Earth, must be different from those last assigned. Let us try therefore what his Distance must be, that this Limit of equal Attraction between him and the Earth may fall without the Orbit of the Moon.

It has been observed before (N°. 99.) that the greater the Quantity of Matter in the Sun is, or the greater the Distance between him and the Earth is supposed to be, the nearer the Limit where they attract equally will approach to the Earth. Thus if we make his Parallax 6″, and therefore his Distance from us 34377 Semi-diameters of the Earth, according to the celebrated Mr. *De le Hire*, by proceeding as before, the Quantity of Matter in him will be to the Matter in the Earth, as 1024820 to 1. The Square Root of 1024820 is 1012, and $\frac{34}{10}\frac{34}{12}\frac{7}{2} = 34$. Whence the Limit of equal Attraction then between the Sun and Earth will be but

about 34 Semi-diameters of the Earth from its Center. On this Supposition therefore, the Force of the Earth to retain the Moon in her Orbit would be little more than a 4th Part of the Sun's Force to draw her from it.

If we make the Sun's Parallax 12″, the double of the last, his Distance from us will be one half of the former, or 17188 Semi-diameters of the Earth; and the Quantity of Matter in him will be as 128102, the Matter in the Earth being still as unity. The Square Root of 128102 is 357; and $\frac{17188}{357}$ =48. The Point of equal Attraction therefore should be but 48 Semi-diameters of the Earth from its Center; and its Force at 60, or 63 Semi-diameters Distance, would still be much too weak to keep the Moon in her Orbit.

If the Parallax should be supposed 20, or the Sun's Distance from the Earth 10000 of its Semi-diameters; the Quantities of Matter in the Sun and Earth will be as 25230 and 1. The Square Root of 25230 is 158; and the Distance of the Limit of equal Attraction will be $\frac{10000}{158}$= 63 Semi-diameters of the Earth from its Center. Here the Sun and Earth's Forces would be but equal in the Moon's *Apogæum*; whence still there is nothing, no Cause to make her mount up again towards the Earth's Orbit, after her Conjunction. Lastly,

Lastly, Let us suppose that the Distance of the Earth from the Sun is only 8000 of its own Semi-diameters; or that the parallactick Angle is 26″; and the Quantities of Matter in the Sun and Earth then will be as 12917,8 and 1. Here (the Square Root of 12917, 8 being 113,6) the whole Distance TS will be expressed by double that Root, or 227,2; and Td, or 1+x is equal to $1\frac{112,6}{114,6}$ =1,982 of the whole Distance. Wherefore $\frac{227,2}{1,982}$=114,6; and $\frac{8000}{114,6}$=69,8 Semi-diameters of the Earth. Here perhaps we may stop, having got the Point of equal Attraction between the Sun and Earth, without the Orbit of the Moon: But sooner I think we cannot stop. For when the Sun is at this Distance from us, the Force of the Earth upon the Moon at her middle Distance, is to the Force of the Sun upon her, only as 1,334 to 1: And in the *Apogæum*, it is but as 1,227 to 1; which cannot be too much, that the Earth may have the Command of its own Satellite. We will rather, I believe, think it too little, if we consider an Observation made by the learned Doctor *Halley*, which has a Relation to this Matter.

It hath been observed before that, if the Distance of the Earth from the Sun be 21000 of its own Semi-diameters, its mean Motion will be at the Rate of a 1000 *English* Miles

in a Minute. Or, if its Distance were (according to M. *De la Hire)* 34377 such Semi-diameters, it must move at the Rate of 1635 Miles in a Minute. And yet the learned Gentleman just now mentioned thinks it great that it should move at the Rate of 210 Miles in a Minute. In his Observation of *Mercury* in the Sun at St. *Helena*, 1677, he says that the annual Motion of the Earth is so exceeding swift, as far to exceed that of a Bullet shot out of a Cannon, and to be after the Rate of 3 *English* Miles and a half in a Second, which is 210 Miles in a Minute, or 12600 Miles in an Hour*. Here it may not be amiss to consider what the Earth's Distance from the Sun would be, according to this Velocity of Motion in a Minute.

The Minutes in a Year are 525969. The Miles then in the Earth's annual Orbit will be $210 \times 525969$, or 1104543490 *English* Miles. The Diameter of the Earth itself is, according to Mr. *Norwood*'s Mensuration, 7967,7 such Miles. But 1104543490 divided by 7967,7 gives us 13862,6. That is, the Miles in the whole annual Orbit divided by the Miles in the Earth's own Diameter, gives us the Number of Diameters in the whole Circumference of the Orbit, *viz.* 13862,6;

* See Doctor *Harris*'s *Lexicon Technicum*, in the Word *Earth*, Vol. I.

if

if its Motion be 210 Miles in a Minute. And there will be just as many Semi-diameters of the Earth, in half the Circumference of the Orbit.—The Proportion between the Semi-circle and Radius, is that of 314159 to 100000. Therefore in the present Case it will be, as 314159 to 100000; so half the Circumference of the Earth's annual Orbit expressed in Semi-diameters of the Earth itself, *viz.* 13863, to 4412,7, the Radius of the Orbit expressed in the same Semi-diameters of the Earth.——Thus, if 210 Miles be the Earth's annual Motion in a Minute, its mean Distance from the Sun will not be above 4413 of its own Semi-diameters. This will surprise those who have been accustomed to think of 20000 or 30000 Semi-diameters Distance; and yet any ingenious Person, how little soever skilled in these Affairs, may try this easy Calculation for his own Satisfaction. As 4413 is a great deal less than 8000 Semi-diameters, this lesser Distance will throw the Point of equal Attraction between the Sun and Earth still much farther from the Center of the Earth, than 69 or 70 Semi-diameters; and therefore still farther without the Orbit of the Moon: Which, if we reflect how far the Satellites of *Jupiter* and *Saturn* lye within this *Limit* between the Sun and their Primaries, is not at all improbable.

bable. For though we ſhould allow (as is but reaſonable) that it is ſcarcely poſſible to make ſuch Obſervations with the laſt Degree of Exactneſs, yet it is hard to ſuppoſe that this Great Man aſſigned to the Earth little more than the fifth Part of its real Velocity.

If the Sun's Diſtance from the Earth be 8000 Semi-diameters, (and it is far more probable that it ſhould be leſs than greater) the Earth's Motion in a Minute will be 381 Miles. If their Diſtance ſhould be 7000 Semi-diameters of the Earth; which Dr. *Keill* ſays is the only Thing that is certain, from the ſeveral Methods of obſerving the Parallax; the Motion of the Earth will be about 333 $\frac{3}{8}$ Miles in a Minute. So that Doctor *Halley*'s Obſervation cannot be ſo wide as the common Parallax of 10 Seconds would make it. But theſe Things I leave to the Conſideration of better Judges.

There were ſome other Particulars in the *Latin* Note, concerning the Weight of Bodies on the Surface of the Sun, his Diameter and Denſity, on the Suppoſition that his Diſtance from us was 8000 Semi-diameters of the Earth; which I omit, ſince it ſeems plain that his Diſtance is not ſo great. I ſhall only take notice of one Thing mentioned there, *viz.* That what-ever the Sun's Diſtance from the Earth may be, his attractive

Force

Force on the Earth will be such as to hinder it with the Moon to roll round their common Center of Gravity. The only Thing that could make the Earth revolve about this Center must be the attractive Force of the Moon upon it; which Force must surely have this Effect, if no other Force intervened; as was observed in N°. 96. in the Seventh Conference. But if a Force many Times stronger than this detains the Earth, it cannot yield to a weaker in Opposition to such stronger Force. This will be plain if we consider, that the Earth in revolving about this Center must sometimes rise to an absolutely greater Distance from the Sun, and then fall down through a certain Space nearer him: For (as was observed N°. 97.) it is the common Center of Gravity between it and the Moon, that keeps always at an equal Distance from him. And if the Earth could not make the Moon rise in Opposition to the Sun's stronger Action upon her, much less could the Moon make the Earth rise in Opposition to the same Action. As in that Case we considered the Point of equal Attraction between the Sun and the Earth, so in this we must consider the Point of equal Attraction between the Sun and the Moon. Which Point, if the Earth's Distance from the Sun be 21000 of its own Semi-

diameters,

diameters, is hardly 7 such Semi-diameters from the Center of the Moon; and if the Distance be but 8000 Semi-diameters, the Point of equal Attraction between the Sun and Moon is not yet above 11 such Semi-diameters from her Center. On the former Supposition the Sun's Force upon the Earth is to the Moon's Force upon it as 76 to 1; and on the latter, as 29 to 1. And if a Force as 29 were overcome by 1, certainly the Force as 28 would be overcome by nothing. There is no explaining, by any *Example* or *Simile*, (as has been endeavoured) how the Earth and Moon may revolve about their common Center of Gravity, in a mechanical manner, unless each of them attracted the other more than the Sun does: That is, unless each of them revolved within the Limit of equal Attraction between the other and the Sun. And even then their Motion about this imaginary Point would be any Thing rather than *mechanical*. I desire any one seriously to read N°. 97, above, and then to declare whether he thinks that such a Motion, as this is there shewn to be, could either be performed or explained mechanically.

*The End of the Second Volume.*

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